

EVALUATION OF ATV USE ON GROOMED SNOWMOBILE TRAILS

Part 2: Appendixes A – D



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Evaluation of ATV Use On Groomed Snowmobile Trails

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APPENDIX A: SUMMARY OF DAILY FIELD TESTING JOURNALS WITH PHOTO DOCUMENTATION

Field Testing Journal: January 9, 2006
New Effington – Northeast Trail, South Dakota
(SD 1)

Field Study Code/Number: SD 1

Location: Northeast Trail east of New Effington, South Dakota along SD Highway 127

Elevation: 1090 feet

Temperature: 28.7 F/-1.8 C (start) to 26.7 F/-2.9 C (end)

Time of Day: 10:05 AM to 1:12 PM

Weather: clear, sunny, 2 mph/3.2 kph wind

Trail Aspect: flat, located in highway road ditch

Trail Conditions: hard packed and very slight surface wear from weekend traffic; last groomed 3 days prior (groomed Friday, tested on Monday) but in good condition; traces of new snow on surface from wind drifting the prior evening

Compacted Snow Depth: 18 cm (7.1 in) at location 1 (the slow/normal track) and 22 cm (8.7 in) at location 2 (the fast/aggressive track); both sites were packed hard to the ground.

Uncompacted snow depth adjacent to the trail: 30 to 40 cm (12 to 16 inches)

Area Grooming Equipment: Tucker 2000 with Mogul Master 18-08 drag



Photo 1: Site of SD 1 field test

Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / ½” lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / ½” lugs, 4 psi)

S1 – 2006 Polaris Switchback 900 (144 x 15 x 1¼” track)

S2 – 2006 Polaris RMK 700 (144 x 15 x 2” track)

Other Vehicles

S3 – 2005 Arctic Cat Firecat F7 (131 x 13½ x 13/8” track / 153 1½” picks)

Individual Vehicle Observations

A1: 2005 Polaris Sportsman 700 ATV

Slow/normal track – generally, all starts, stops and 15 mph/24 kph pass-bys resulted in visible tire tread tracks that were 2 to 3 cm (0.8 to 1.2 in) deep and 18 to 21 cm (7.1 to 8.3 in) wide. Tire tracks were generally consistently visible and the same the entire length of the start and pass-by zones. Four passes were run in 4x4 mode and another 4 passes were run in 2x4 mode. Results were generally similar with only slightly more rear tire spin in the 2x4 mode. Since there was insignificant difference observed between the 4x4 and 2x4 testing, it was decided that all additional tests with this vehicle would be conducted only in the 4x4 mode.



Photo 2: Surface chew from slow pass-by

Fast/aggressive track – starts resulted in tire tracks that varied from 2 to 7 cm (0.8 to 2.8 in) deep, 18 to 20 cm (7.1 to 7.9 in) wide and 300 to 360 cm (9.8 to 11.8 feet) in length. The 35 mph/56 kph pass-by resulted in visible tire tracks 2 to 3 cm (0.8 to 1.2 in) deep and 18 to 21 cm (7.1 to 8.3 in) wide and left no visible trenching or

rutting. Stops resulted in tire impressions that varied from 2 to 13 cm (0.8 to 5.1 in) deep and 22 to 30 cm (8.7 to 11.8 in) wide. Stopping distance at 35 mph/56 kph ranged from 18.7 to 21.6 meters (61.4 to 70.9 feet), with an average stopping distance of 19.8 meters (65 feet).



Photo 3: Aggressive start



Photo 4: Aggressive stop

Other – the vehicle got stuck twice. The first time was when the operator tried to turn around off the trail surface. The vehicle sunk in to its axles before it could make it back onto the trail. (The tracks to the right of the trail in Photo 5) The second time was when the right wheels of the ATV got off the edge of the packed base while it was going down the trail and the right tires were sucked into the softer snow adjacent to the trail.



Photo 5: Tracks at right where vehicle got stuck



Photo 6 (above): ATV stuck off-trail

A2: 2006 Polaris Predator 500 ATV

Slow/normal track – generally, all starts, stops and 15 mph/24 kph pass-bys resulted in visible tire tread tracks that were 2 cm (0.8 in) deep and 28 to 30 cm (11 to 11.8 in) wide. Tire tracks were generally visible and consistent the entire length of the start and pass-by zones.

Photo 7: Surface chew from slow pass-by



Fast/aggressive track – starts resulted in tire tracks that varied from 3 to 6 cm (1.2 to 2.4 in) deep and 27 to 30 cm (10.6 to 11.8 in) wide. The 35 mph/56 kph pass-bys resulted in visible tire tracks 2 cm (0.8 in) deep and 27 to 30 cm (10.6 to 11.8 in) wide and left no visible trenching or rutting. Stops resulted in tire impressions that varied from 4 to 5 cm (1.6 to 2 in) deep and 27 to 30 cm (10.6 to 11.8 in) wide. Stopping distance at 35 mph/56 kph ranged from 22.7 to 31.9 meters (74.5 to 104.7 feet), with an average stopping distance of 27.7 meters (90.7 feet).



Photo 8: Tracks from aggressive start



Photo 9: Tracks and snow piles from acceleration

Other – the vehicle got stuck twice. The first time was when the operator was attempting a 3-point turn around and the rear wheels dropped off the packed trail surface. The vehicle sunk in to the rear axle – see the impressions left in Photo 10 at right. The second time was when the right wheels of the vehicle got off the packed base while it was going down the trail. The ATV was sucked into the softer snow adjacent to the side of the trail. See Photos 11 and 12.



Photo 10: Tracks where vehicle was stuck beside trail



Photo 11: Stuck on edge of trail



Photo 12: Stuck vehicle

S1: 2006 Polaris Switchback 900 Snowmobile
Slow/normal track – generally, all starts, stops and 15 mph/24 kph pass-bys resulted in 2.5 cm (1 in) deep grooves from the ski skags and normal “surface chew” from the track that was 2 to 3 cm (0.8 to 1.2 in) deep and 38 to 40 cm (15 to 15.7 in) wide. The skag marks and surface chew were generally consistently visible and the same the entire length of the start, pass-by, and stop zones, consistent with trail wear from normal snowmobile traffic.



Photo 13: Surface chew from slow pass-by

Fast/aggressive track – starts resulted in track marks that varied from 2 to 3 cm (0.8 to 1.2 in) deep and 40 to 43 cm (15.7 to 16.9 in) wide. There were also 2.5 cm (1 in) deep ski skag grooves. The 35 mph/56 kph pass-bys resulted in normal “surface chew” from the track that was 2 to 3 cm (0.8 to 1.2 in) deep and 38 to 40 cm (15 to 15.7 in) wide), along with the 2.5 cm (1 in) deep ski skag grooves. There was no visible trenching or rutting. Stops resulted in track impressions that varied from 2 to 3 cm (0.8 to 1.2 in) deep and 42 to 43 cm (16.5 to 16.9 in) wide. Stopping distance at 35 mph/56 kph ranged from 22.5 to 25.2 meters (73.8 to 82.7 feet), with an average stopping distance of 23.6 meters (77.4 feet)



Photo 14: Impressions from aggressive stop



Photo 15: Aggressive stop



Photo 16: Surface chew from fast pass-by

S2: 2006 Polaris RMK 700 Snowmobile

Slow/normal track – generally, all starts, stops and 15 mph/24 kph pass-bys resulted in 2.5 cm (1 in) deep grooves from the ski skags and normal “surface chew” from the track that was 2.5 to 4 cm (1 to 1.6 in) deep and 38 to 40 cm (15 to 15.7 in) wide. The skag marks and surface chew were generally consistently visible and the same the entire length of the start, pass-by, and stop zones, consistent with trail wear from normal snowmobile traffic.



Photo 17: Surface chew from slow pass-by

Fast/aggressive track – starts and stops both resulted in track marks that varied from 5 to 6 cm (2 to 2.4 in) deep and 42 to 43 cm (16.5 to 16.9 in) wide, along with 2.5 cm (1 in) deep ski skag grooves. The start left trenching while the stop left slide marks – both more prominent than those left by S1 which has shorter track lugs. The 35 mph/56 kph pass-bys resulted in impressions from the track that were 2.5 to 4 cm (1 to 1.6 in) deep and 38 to 40 cm (15 to 15.7 in) wide, along with 2.5 cm (1 in) deep ski skag grooves. There was no visible trenching or rutting. Stopping distance at 35 mph/56 kph ranged from 20.2 to 23.2 meters (66.3 to 76.1 feet), with an average stopping distance of 21.5 meters (70.5 feet).



Photo 18: An aggressive start



Photo 19: An aggressive stop

S3: 2005 Arctic Cat Firecat F7 Snowmobile

Slow/normal track – generally, all starts, stops and 15 mph/24 kph pass-bys resulted in ski skag grooves that were 2.5 cm (1 in) deep and normal “surface chew” from the track that was 2 to 3 cm (0.8 to 1.2 in) deep and 35 cm (13.8 in) wide. The skag marks and surface chew were generally consistently visible and the same the entire length of the start, pass-by, and stop zones, consistent with trail wear from normal snowmobile traffic.

Fast/aggressive track – starts resulted in track marks that varied from 4 to 10 cm (1.6 to 3.9 in) deep and were generally 35 cm (13.8 in) wide, along with 2.5 cm (1 in) deep ski skag grooves. The 35 mph/56 kph pass-by resulted in 2 to 3 cm (0.8 to 1.2 in) deep and 35 cm (13.8 in) wide “surface chew” from the track, along with 2.5 cm (1 in) deep ski skag grooves. There was no visible trenching or rutting. Stops resulted in track impressions that varied from 3 to 4 cm (1.2 to 1.6 in) deep and were 35 to 38 cm (13.8 to 15 in) wide. Stopping distance at 35 mph/56 kph ranged from 16.5 to 18.9 meters (54.1 to 62 feet), with an average stopping distance of 17.3 meters (56.8 feet).



Photo 20: Surface chew from slow pass-by



Photo 21: Impression from aggressive start



Photo 22: An aggressive stop

Summary of Observations from SD 1 Field Test

- **SLOW/NORMAL OPERATION:** None of the vehicles created noticeable adverse impacts when operated in the slow/normal mode whether in the start, 15 mph/24 kph pass-by, or stop zones.
- **FAST/AGGRESSIVE PASS-BY:** None of the vehicles created noticeable adverse impacts when operated in the 35 mph/56 kph pass-by mode.
- **AGGRESSIVE STARTS:** Snowmobiles created deeper impressions in the trail than what ATVs did. Aggressive starts resulted in ATV tire tracks 3 to 7 cm (1.2 to 2.8 in) deep and 18 to 30 cm (7.1 to 11.8 in.) wide. Snowmobile track impressions were 2 to 10 cm (0.8 to 3.9 in) deep and 35 to 43 cm (13.8 to 16.9 in.) wide. The deepest snowmobile track impressions were 3 cm (1.2 in) deeper than the deepest ATV tire tracks.
- **AGGRESSIVE STOPS:** ATVs created deeper impressions in the trail than what snowmobiles did. Aggressive stops resulted in ATV tire tracks 2 to 13 cm (0.8 to 5.1 in) deep and 22 to 30 cm (8.7 to 11.8 in) wide. Snowmobile track impressions were 2 to 5 cm (0.8 to 2 in) deep and 35 to 43 cm (13.8 to 16.9 in) wide. The deepest ATV tire tracks were 8 cm (3.1 in) deeper than the deepest snowmobile track impressions.

- **STOPPING DISTANCE – ALL VEHICLES:** When comparing all vehicles tested, the snowmobiles generally stopped quicker than what the ATVs did. The Sportsman stopped the quicker of the two ATVs, while the Firecat stopped the quickest of the three snowmobiles. The Switchback required the greatest distance to stop of the three snowmobiles. Average ATV stopping distance at 35 mph/56 kph ranged from 19.8 to 27.7 meters (65.0 to 90.7 feet). The average snowmobile stopping distance ranged from 17.3 to 23.6 meters (56.8 to 77.4 feet). The minimum average snowmobile stopping distance (the Firecat) was 2.5 meters/8.2 feet (14.5%) less than the shortest ATV stopping distance, while the maximum average ATV stopping distance (the Predator) was 4.1 meters/13.3 feet (17.2%) greater than the longest average snowmobile stopping distance.
- **STOPPING DISTANCE – CONTROL VEHICLES:** When comparing just the four control vehicles, the results were mixed. The Sportsman stopped quicker of the two control ATVs, while the Switchback required the greatest distance to stop of the two control snowmobiles. The Sportsman ATV stopped quicker than both snowmobiles, while the Predator ATV required a longer distance to stop than what the snowmobiles did. The average ATV stopping distances at 35 mph/56 kph ranged from 19.8 to 27.7 meters (65.0 to 90.7 feet), while the average snowmobile stopping distance ranged from 21.5 to 23.6 meters (70.5 to 77.4 feet). The minimum average ATV stopping distance (the Sportsman) was 1.7 meters/5.6 feet (8.6%) less than the shortest average snowmobile stopping distance, while the maximum average ATV stopping distance (the Predator) was 4.1 meters/13.5 feet (17.4%) greater than the snowmobiles.
- Both ATVs immediately became stuck when they got off the packed trail base.
- Note: Due to the narrower width (8 feet) of this trail, ATVs were tested first, followed by snowmobiles on the same track. On all subsequent tests, ATVs and snowmobiles were tested side-by-side on wider trails.

Field Testing Journal: January 9, 2006
Lake Traverse – Northeast Trail. South Dakota (SD 2)

Field Study Code/Number: SD 2

Location: adjacent to Lake Traverse on the Northeast Trail, South Dakota

Elevation: 1050 feet

Temperature Range: 28.0 F/-2.2 C (start) to 18.5 F/-7.5 C (end)

Time of Day: 4:12 PM to 4:48 PM

Weather: clear, sunny, 3 mph/4.8 kph wind

Trail Aspect: south facing, 19% grade for 320 feet/97.5 meters, located in county road ditch

Trail Conditions: hard packed and very slight surface wear from weekend traffic; last groomed 3 days prior (groomed Friday, tested on Monday) but in good condition; traces of new snow on surface from wind drifting the prior evening

Compacted Snow Depth: 40 cm (15.7 in) – packed hard to ground

Uncompacted snow depth adjacent to the trail: greater than 60 cm (24 in)

Area Grooming Equipment: Tucker 2000 with Mogul Master 18-08 drag



Photo 23: Site of SD 2 testing

Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / ½” lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / ½” lugs, 4 psi)

S1 – 2006 Polaris Switchback 900 (144 x 15 x 1¼” track)

S2 – 2006 Polaris RMK 700 (144 x 15 x 2” track)

Other Vehicles

S3 – 2005 Arctic Cat Firecat F7 (131 x 13½ x 13/8” track / 153 1½” picks)

Individual Vehicle Observations

A1: 2005 Polaris Sportsman 700 ATV

Hill pass-by – the vehicle struggled with the steepness of the grade, so all uphill pass-bys would be considered ‘aggressive’ versus ‘normal.’ The vehicle’s tires were spinning all the way up the hill on all uphill passes, making it hard to control and keep straight while climbing. Impressions from the tire tracks were 10 to 12 cm (3.9 to 4.7 in) deep and 20 cm (7.9 in) wide on the uphill passes. Tire impressions left by downhill passes varied from 2 to 5 cm (0.8 to 2 in) in depth and were 20 cm (7.9 in) wide.



Photo 24: An uphill pass



Photo 25: Impressions from an uphill pass



Photo 26: Impressions from a downhill pass

A2: 2006 Polaris Predator 500 ATV

Hill pass-by – the vehicle struggled with the steepness of the grade and had a hard time making it up the hill, so all uphill pass-bys would be considered ‘aggressive’ versus ‘normal.’ The vehicle was swerving and hard to control with its tires spinning all the way up the hill on all uphill passes. Impressions from the tire tracks were 10 to 12 cm (3.9 to 4.7 in) deep and 28 to 30 cm (11 to 11.8 in) wide on the uphill passes. Downhill passes left only 2 cm (0.8 in) impressions of the tire tread (due to the flatter tire design) with no visible impact to the trail.



Photo 27: An uphill pass



Photo 28: Impressions from an uphill pass



Photo 29: Impressions from an uphill pass



Photo 30: Tire impressions from a downhill pass

S1: 2006 Polaris Switchback 900 Snowmobile

Hill pass-by – Slow/normal uphill and downhill pass-bys actually helped to somewhat re-level the trail surface after the ATVs had rutted the hill. On slow/normal pass-bys at 15 mph/24 kph, both uphill and downhill, the vehicle left only skag marks and normal track marks with minimal surface chew 2 cm (0.8 in) deep. On fast/aggressive runs at 32 to 35 mph/ 51 to 56 kph, only normal track marks (surface chew) 2 cm (0.8 in) deep and 40 cm (15.7 in) wide were left on the trail. 2 cm (0.8 in) deep ski skag marks were also visible. There was no spinning or rutting during slow/normal or fast/aggressive passes, up or down hill.

S2: 2006 Polaris RMK 700 Snowmobile

Hill pass-by – Results were identical to those of the Switchback (S1) runs. Slow/normal uphill and downhill pass-bys actually helped to re-level trail surface after the ATVs had rutted the hill. On slow/normal pass-bys at 15 mph/24 kph, both uphill and downhill, the vehicle left only skag marks and minimal surface chew track marks.



Photo 31: A downhill pass

On the fast/aggressive runs at 32 to 35 mph/ 51 to 56 kph, only 2 cm (0.8 in) deep track surface chew and 2 cm (0.8 in) deep ski skag marks were left on the trail. There was no spinning or rutting during slow/normal or fast/aggressive passes, up or down hill.



Photos 32 and 33: The hill after snowmobile passes – note that the ATV tire marks were re-leveled

S3: 2005 Arctic Cat Firecat F7 Snowmobile Hill pass-by – Results were identical to those of the S1 and S2 runs. On slow/normal pass-bys at 15 mph/24 kph, both uphill and downhill, the vehicle left only skag marks and normal track marks with minimal surface chew. On the fast/aggressive runs at 32 to 35 mph/ 51 to 56 kph, only track surface chew marks 2 cm (0.8 in) deep and 2 cm (0.8 in) deep ski skag marks were left on the trail. There was no spinning or rutting during slow/normal or fast/aggressive passes, up or down hill.



Photo 34: An uphill pass

Summary of Observations from SD 2 Field Test

- **ATV PASS-BYS:** Both ATVs struggled, were hard to control, and were hard to keep going straight when climbing the 19% grade. When going downhill, they primarily left only 2 cm (0.8 in) deep tire tread tracks on the trail. However, when traveling uphill, they cut 10 to 12 cm (3.9 to 4.7 in) deep and 20 to 30 cm (7.9 to 11.8 in) wide tire ruts into the trail.
- **SNOWMOBILE PASS-BYS:** The snowmobiles had no problems climbing or descending the 19% grade, remained fully under control, and actually helped to re-level the trail surface after the ATVs had cut ruts into it. When traveling downhill and uphill, they left only minimal surface chew about 2 cm (0.8 in) in depth. There was no spinning or rutting during the slow/normal or the fast/aggressive passes, up or down hill.

Field Testing Journal: January 10, 2006
Sica Hollow State Park – Northeast Trail, South Dakota (SD 3)

Field Study Code/Number: SD 3

Location: Sica Hollow State Park on the Northeast Trail, South Dakota

Elevation: 1626 feet

Temperature Range: 31.2 F/-0.4 C (start) to 27.0 F/-2.8 C (end)

Time of Day: 10:45 AM to 12:15 PM

Weather: clear, sunny, 10 to 15 mph / 16 to 24 kph wind

Trail Aspect: Site 1 - 180 degree curve, flat at one end with a 3% grade at the other end, 300 feet/91 meters in length; Site 2 - 90 degree curve with 10% grade throughout the corner, 225 feet/68.6 meters in length

Trail Conditions: hard packed and very slight surface wear from weekend traffic; last groomed 4 days prior (groomed Friday, tested on Tuesday) but in good condition; traces (0 to 2 cm/0.8 in) of loose snow on surface from wind drifting the prior days

Compacted Snow Depth: 180 degree curve – 19 cm (7.5 in.) hard compaction to ice layer; 90 degree curve – 15 cm (5.9 in.) hard compaction to ice layer

Uncompacted snow depth adjacent to the trail: 38 cm (15 in)

Area Grooming Equipment: Tucker 2000 with Mogul Master 18-08 drag



Photo 35: SD 3 site – 180 degree curve/3% grade



Photo 36: SD 3 site – 90 degree curve/10% grade

Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / ½” lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / ½” lugs, 4 psi)

S2 – 2006 Polaris RMK 700 (144 x 15 x 2” track)

Individual Vehicle Observations

A1: 2005 Polaris Sportsman 700 ATV

180 degree curve with 3% grade pass-by – slow/normal passes at 15 mph/24 kph resulted in surface chew 3 cm (1.2 in) deep and 28 cm (11 in) wide. No tire impressions got into the compacted trail base. The first two fast/aggressive runs at 30 to 35 mph/48 to 56 kph resulted in 4 cm (1.6 in) deep and 30 cm (11.8 in) wide tire impressions. The third and fourth passes resulted in a berm, 20 cm (7.9 in) high and 30 cm (11.8 in) wide, being formed on the outside edge of the tire tracks.



Photo 37: A slow pass-by



Photo 38: Impressions from a fast pass-by



Photo 39: An aggressive pass-by



Photo 40: Berm created by fast pass-bys

90 degree curve with 10% grade pass-by – slow/normal downhill passes at 15 mph/24 kph resulted in surface chew 2 cm (0.8 in) deep and 20 cm (7.9 in) wide, while uphill passes generated surface chew 3 cm (1.2 in) deep and 28 cm (11 in) wide due to slightly more tire spin. Fast/aggressive passes at 30 to 35 mph/48 to 56 kph produced similar results, irrespective of uphill or downhill travel, and resulted in tire impressions 5 to 7 cm (2 to 2.8 in) deep and 28 cm (11 in) wide on the first two passes. The third and fourth fast repetitions resulted in tire ruts that were 14 cm (5.5 in) deep and 32 to 40 cm (12.6 to 15.8 in) wide.



Photo 41: Surface chew from slow pass-by



Photo 42: Tire impressions from fast pass-by

Other – the testing sites for the two curves required a three mile ride on the groomed trail system to reach the two test sites. At one point the operator pulled to the side of the trail to allow a snowmobile to pass. The outside wheels got off the compacted trail base and the vehicle was sucked into the soft, unpacked snow beside the trail, resulting in the vehicle becoming stuck.

A2: 2006 Polaris Predator 500 ATV

180 degree curve with 3% grade pass-by – slow/normal passes at 15 mph/24 kph resulted in surface chew that was 2 cm (0.8 in) deep and 25 cm (9.8 in) wide. No tire impressions got into the compacted trail base. There was a slight (3%) grade at one end of the curve and the fast/aggressive downhill runs at 25 to 30 mph/40 to 48 kph resulted in tire impressions 7 to 9 cm (2.8 to 3.5 in) deep and 30 cm (11.8 in.) wide. The uphill fast passes resulted in 13 cm (5.1 in) deep by 40 to 43 cm (15.8 to 16.9 in) wide tire tracks. The vehicle was sliding and generating a full snow spray on all aggressive runs.



Photo 43: A slow pass-by



Photo 44: Surface chew from slow pass-by



Photo 45: An aggressive pass-by



Photo 46: Berm from aggressive pass-bys

90 degree curve with 10% grade pass-by – slow/normal passes, uphill and downhill at 15 mph/24 kph, resulted in surface chew that was 2 cm (0.8 in) deep and 32 cm (12.6 in) wide. Fast/aggressive passes at 25 to 30 mph/40 to 48 kph produced similar results, irrespective of uphill or downhill travel, and resulted in tire impressions that were 9 cm (3.5 in) deep and 30 cm (11.8 in) wide on the first two passes. The third and fourth repetitions resulted in tire ruts that were 14 cm (5.5 in) deep and 30 cm (11.8 in) wide. The vehicle was sliding and generating a full snow spray on all aggressive runs.



Photo 47: An aggressive pass-by



Photo 48: Impressions from an aggressive pass-by

Other – the testing sites for the two curves required a three mile ride on the groomed trail system to reach the two test sites. As the operator came around the 90 degree curve while moving between test sites, the outside wheels of the ATV got off the compacted trail base and the vehicle was sucked into the softer, unpacked snow beside the trail. The curve was windswept, so it was difficult to tell exactly where the groomed trail edge was since it all looked like it was hard packed. It is estimated that the ATV was traveling at approximately 25 to 30 mph / 40 to 48 kph when it came through the curve. The result of the ATV's right front tire dropping off the compacted trail base at this speed was that the ATV flipped end-over-end. It came to rest upside-down facing the opposite direction than it had been traveling. Fortunately there were no injuries to the operator or damage to the vehicle.



Photo 49: ATV that flipped over



Photos 50 and 51: ATV flipped end-over-end when its right tires got off the compacted trail base

S2: 2006 Polaris RMK 700 Snowmobile

180 degree curve with 3% grade pass-by – slow/normal passes at 15 mph/24 kph resulted in surface chew 3 cm (1.2 in) deep and 40 cm (15.8 in) wide and ski skag marks that were 2 cm (0.8 in) deep. No track or ski impressions got into the compacted trail base. The first three fast/aggressive runs at 30 mph/48 kph resulted in track marks 4 to 9 cm (1.6 to 3.5 in) deep and 45 cm (17.7 in) wide. The fourth pass resulted in a 20 cm (7.9 in) high berm being formed on the outside edge of the track.



Photo 52: Fast pass-by

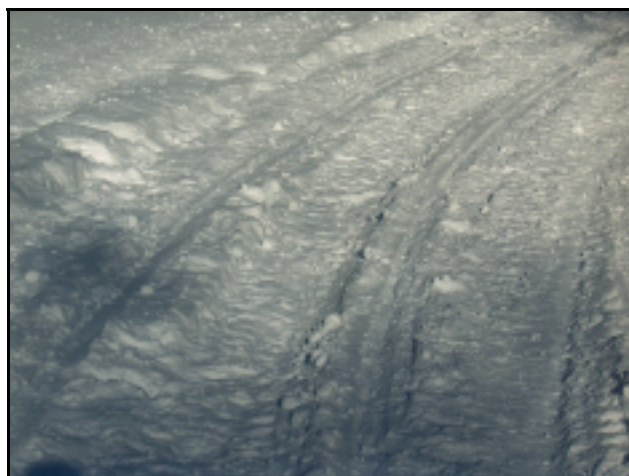


Photo 53: Impressions from a slow pass-by



Photo 54: Impressions from a fast pass-by

90 degree curve with 10% grade pass-by – slow/normal passes, up and down hill at 15 mph/24 kph, resulted in surface chew 2 cm (0.8 in) deep and 45 cm (17.7 in) wide and ski skag marks 2 cm (0.8 in) deep and. No track or ski impressions got into the compacted trail base. The fast/aggressive runs at 30 mph/48 kph resulted in track marks 3 to 4 cm (1.2 to 1.6 in) deep and 45 cm (17.7 in) wide when traveling downhill. The track marks were the same depth but 100 cm (39.4 in) wide when traveling uphill due to more ‘sliding’ action through the corner. No ruts or berms were created even though there was significant snow spray during each aggressive pass-by (but less spray than from A2/the Predator ATV during its aggressive runs). The snowmobile’s track was displacing/spraying surface snow versus digging snow from the compacted trail base.



Photo 55: Impressions from a fast pass-by

Other – the testing sites for the two curves required a three mile ride to reach the two test sites. Since there were only three people on the test crew, the decision was made to initially take the two ATVs and the snowmobile with the most aggressive track (S2 = 2” versus S1 = 1¼”) for the initial testing. Since the S2 pass-bys did not indicate substantive impacts to the trail base, it was decided it was unnecessary to make the 3-mile trip back to

the trailer for the second snowmobile (S1) with the less aggressive track. Therefore, only one control snowmobile was run for these two curve tests.

Summary of Observations from SD 3 Field Test

- **SLOW/NORMAL OPERATION:** None of the vehicles created noticeable adverse impacts to the trail base on either curve when operated in the slow/normal mode at 15 mph/24 kph. There was only normal surface chew.
- **FAST/AGGRESSIVE ATV OPERATION:** Fast/aggressive passes by the ATVs generated tire impressions 5 to 14 cm (2 to 5.5 in) deep that were 30 to 43 cm (11.8 to 16.9 in) wide. A berm was also generated on the outside edge of the 180 degree corner that was 20 cm (7.9 in) high.
- **FAST/AGGRESSIVE SNOWMOBILE OPERATION:** Fast/aggressive passes by the snowmobile generated track marks 4 to 9 cm (1.6 to 3.6 in) deep and 45 to 100 cm (17.7 to 39.4 in) wide. A berm was also generated on the outside edge of the 180 degree corner that was 20 cm (7.9 in) high.
- The Sportsman ATV (A1) became stuck when its outside wheels dropped off the compacted/groomed trail base when traveling on the trail between testing sites. The Predator ATV (A2) flipped end-over-end off the trail when its outside wheels dropped off the compacted/groomed trail base when traveling on the trail between testing sites.

Field Testing Journal: January 23, 2006 Black Hills, South Dakota (SD 4)

Field Study Code/Number: SD 4

Location: Trail 2 cut-across south of Hardy Camp;
Black Hills of South Dakota

Elevation: 6675 feet

Temperature Range: 21.9 F/-5.6 C (start) to 27.5 F/-2.5 C (end)

Time of Day: 8:38 AM to 11:06 AM

Weather: clear, sunny, 3.5 mph / 5.6 kph wind

Trail Aspect: the slow/normal track was flat; the fast/aggressive had a 4% grade for a distance of 125 feet (38.1 meters) at one end with the balance having a 2% grade

Trail Conditions: freshly groomed within 1 hour of start, very hard

Compacted Snow Depth: 60 cm (23.6 in) to gravel at location 1 (the slow/normal track) and 19 cm (7.5 in) to ice at location 2 (the fast/aggressive track). Both sites were packed very hard to the ground.

Uncompacted snow depth adjacent to the trail: 45.7 to 61 cm (18 to 24 inches)

Area Grooming Equipment: Tucker 2000 TERRA with Mogul Master 18-09 drag



Photo 56: Site of SD 4 field test

Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / ½” lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / ½” lugs, 4 psi)

S1 – 2006 Polaris Switchback 900 (144 x 15 x 1¼” track)

S2 – 2006 Polaris RMK 700 (144 x 15 x 2” track)

Individual Vehicle Observations

A1: 2005 Polaris Sportsman 700 ATV

Slow/normal track – generally, all starts, stops and 15 mph/24 kph pass-bys resulted in “surface chew” from the tires that was 1 to 2 cm (0.4 to 0.8 in) deep and 20 cm (7.9 in) wide. Tire tracks were visible and consistent the entire length of the start and pass-by zones.



Photo 57: A slow pass-by



Photo 58: Tire impression from slow pass-by

Fast/aggressive track – starts resulted in tire tracks that varied from 2 to 5 cm (0.8 to 2 in) deep and 22 to 25 cm (8.7 to 9.8 in) wide. The 35 mph/56 kph pass-bys resulted in visible tire tracks 3 cm (1.2 in) deep and 24 to 25 cm (9.5 to 9.8 in) wide and left no visible trenching or rutting. Stops resulted in tire impressions that were 2 to 3 cm (0.8 to 1.2 in) deep and 18 to 25 cm (7.1 to 9.8 in) wide. Stopping distance at 35 mph/56 kph ranged from 23.2 to 26.9 meters (76.0 to 88.8 feet), with an average stopping distance of 25.5 meters (83.6 feet).



Photo 59: Tire impressions from an aggressive start



Photo 60: Impressions from an aggressive stop

Other – the vehicle got stuck when the operator attempted a 3-point turn around on the trail and the front tires dropped off the compacted trail base. This resulted in ruts from the rear tires spinning that were 9 cm (3.5 in) deep and 26 cm (10.2 in) wide before the vehicle was pushed out. Footprints on the trail surface left impressions in the snow that were 2 cm (0.8 in) deep.

A2: 2006 Polaris Predator 500 ATV

Slow/normal track – generally, all starts, stops and 15 mph/24 kph pass-bys resulted in “surface chew” from the tires that was 1 cm (0.4 in) deep and 25 to 28 cm (9.8 to 11 in) wide. Tire tracks were visible and consistent the entire length of the start and pass-by zones. When the vehicle was shifted between gears, it left 26 cm (10.2 in) wide and 5 cm (2 in) high snow piles, with a 2 cm (0.8 in) deep “dish” beside the snow pile from where the tires bit into the trail surface.

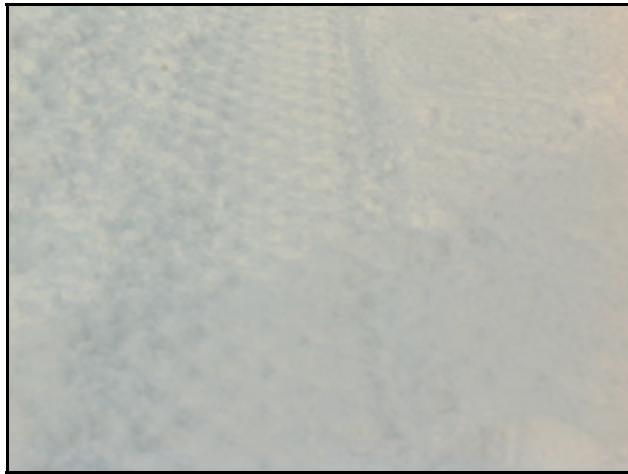


Photo 61: Tire impression from slow pass-by



Photo 62: Snow piles from shifting gears

Fast/aggressive track – starts resulted in tire tracks that 4 to 5 cm (1.8 to 2 in) deep and 25 to 26 cm (9.8 to 10.2 in) wide. The 35 mph/56 kph pass-bys resulted in visible tire tracks 3 cm (1.2 in) deep and 25 cm (9.8 in) wide and left no visible trenching or rutting. Stops resulted in tire impressions that were 3 to 4 cm (1.2 to 1.6 in) deep and 25 to 28 cm (9.8 to 11 in) wide. Stopping distance at 35 mph/56 kph ranged from 17.4 to 21.4 meters (57.0 to 70.3 feet), with an average stopping distance of 19.6 meters (64.4 feet). When the vehicle was shifted to second gear, it left a 5 cm (2 in) high snow pile that backfilled the tire track.



Photo 63: Impressions and piles from a fast start



Photo 64: Impressions from an aggressive stop

S1: 2006 Polaris Switchback 900 Snowmobile

Slow/normal track – generally, all starts, stops and 15 mph/24 kph pass-bys resulted in 1.5 cm (0.6 in) deep grooves from the ski skags and “surface chew” from the track that was 2 cm (0.8 in) deep and 39 cm (15.4 in) wide. The skag marks and surface chew were generally consistently visible and the same the entire length of the start, pass-by, and stop zones, consistent with trail wear from normal snowmobile traffic.



Photo 65: A slow pass-by



Photo 66: Impressions from slow pass-bys

Fast/aggressive track – starts resulted in track marks that were 3 to 6 cm (1.2 to 2.4 in) deep and 39 cm (15.4 in) wide. The 35 to 40 mph/56 to 64 kph pass-bys resulted in “surface chew” from the track that was 2 to 3 cm (0.8 to 1.2 in) deep and 38 to 40 cm (15 to 15.7 in) wide). There was no visible trenching or rutting. Stops resulted in track impressions that were 2 to 3 cm (0.8 to 1.2 in) deep and 39 cm (15.4 in) wide. Stopping distance at 35 to 40 mph/56 to 64 kph ranged from 22.6 to 27.1 meters (74.1 to 89.0 feet), with an average stopping distance of 24.8 meters (81.5 feet).



Photo 67: Surface chew from fast pass-bys



Photo 68: Impression from an aggressive start



Photo 69: Impression from a fast stop

S2: 2006 Polaris RMK 700 Snowmobile

Slow/normal track – generally, all starts, stops and 15 mph/24 kph pass-bys resulted in 0.5 cm (0.2 in) deep 4 cm (1.6 in) wide grooves from the ski skags and surface chew from the track that was 2 cm (0.8 in) deep and 38 to 39 cm (15 to 15.4 in) wide. The skag marks and surface chew were generally visible and consistent the entire length of the start, pass-by, and stop zones, consistent with trail wear from normal snowmobile traffic.



Photo 70: Track surface chew from slow pass-by



Photo 71: Mark from ski skag

Fast/aggressive track – starts resulted in track marks that were 3 to 7 cm (1.2 to 2.8 in) deep and 41 cm (16.1 in) wide. The 35 mph/56 kph pass-bys resulted in surface chew from the track that was 2 to 3 cm (0.8 to 1.2 in) deep and 39 to 41 cm (15.4 to 16.1 in) wide). There was no visible trenching or rutting. Stops resulted in track impressions that were 2 to 5 cm (0.8 to 2 in) deep and 41 cm (16.1 in) wide. Stopping distance at 35 mph/56 kph ranged from 23.3 to 25.9 meters (76.3 to 85.0 feet), with an average stopping distance of 25.0 meters (82.0 feet).



Photo 72: Impression from a fast start



Photo 73: Surface chew from a fast pass-by



Photo 74: Impression from an aggressive stop

Summary of Observations from SD 4 Field Test

- **SLOW/NORMAL OPERATION:** None of the vehicles created noticeable adverse impacts when operated in the slow/normal mode whether in the start, 15 mph/24 kph pass-by, or stop zones.
- **FAST/AGGRESSIVE PASS-BY:** None of the vehicles created noticeable adverse impacts when operated in the 35 mph/56 kph pass-by mode.
- **AGGRESSIVE STARTS:** Snowmobiles created slightly deeper impressions in the trail than what the ATVs did. Aggressive starts resulted in ATV tire impressions 2 to 5 cm (0.8 to 2 in) deep and 22 to 26 cm (8.7 to 10.2 in) wide. Snowmobile track impressions were 3 to 7 cm (1.2 to 2.8 in) deep and 39 to 41 cm (15.4 to

16.1 in) wide. The deepest track impressions from the snowmobiles were 2 cm (0.8 in) deeper than the deepest ATV tire tracks.

- **AGGRESSIVE STOPS:** Snowmobiles created slightly deeper impressions in the trail than what the ATVs did. Aggressive stops resulted in ATV tire impressions 2 to 4 cm (0.8 to 1.8 in) deep and 18 to 25 cm (7.1 to 9.8 in) wide. Snowmobile track impressions were 2 to 5 cm (0.8 to 2 in) deep and 39 to 41 cm (15.4 to 16.1 in) wide. The deepest snowmobile track impressions were 1 cm (0.4 in) deeper than the deepest ATV tire tracks.
- **STOPPING DISTANCE – CONTROL VEHICLES:** When comparing the four control vehicles, the results were mixed. The Predator ATV stopped quicker than both snowmobiles, while the Sportsman required a slightly longer distance to stop than what the two snowmobiles did. The Predator stopped the quicker of the two control ATVs, while the Switchback required the greatest distance to stop of the two snowmobiles. The average ATV stopping distances at 35 mph/56 kph ranged from 19.6 to 25.5 meters (64.4 to 83.6 feet), while the average snowmobile stopping distance ranged from 24.8 to 25.0 meters (81.5 to 82.0 feet). The minimum average ATV stopping distance (the Predator) was 5.2 meters/17.1 feet (21.0%) less than the shortest average snowmobile stopping distance, while the maximum average stopping distance for the Sportsman ATV was just 0.5 meters/1.6 feet (2.0%) greater than the longest average snowmobile stopping distance.
- Both ATVs became stuck when they got off the packed trail base.



Photo 75: Footprints on the trail

- Impressions from footprints on the trail surface were 2 cm (0.8 in) deep.

**Field Testing Journal: January 23, 2006
Black Hills, South Dakota (SD 5)**

Field Study Code/Number: SD 5

Location: Trail 1 alternate southeast of Hardy Camp;
Black Hills of South Dakota

Elevation: 6675 feet

Temperature Range: 31.0 F/-0.6 C (start) to 29.2 F/
-1.6 C (end)

Time of Day: 11:58 AM to 12:35 PM

Weather: clear, sunny, 3.5 mph / 5.6 kph wind

Trail Aspect: this site provided a hill/curve combination over a distance of approximately 0.3 mile (0.48 kilometer). The segment had a 14% to 18% grade over the entire distance; with a 28% grade for a short distance at the crown of the hill. There was a 20 degrees curve about 0.1 mile (0.16 km) from the bottom and a sweeping 35 degrees curve about 0.1 mile (0.16 km) from the top.

Trail Conditions: groomed the prior night, very hard, excellent condition

Compacted Snow Depth: 29 cm (11.4 in) to grass; packed very hard to the ground

Uncompacted snow depth adjacent to the trail: 51 to 76 cm (20 to 30 inches)

Area Grooming Equipment: Tucker 2000 TERRA with Mogul Master 18-09 drag



Photo 76: Site of SD 5 field test

Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / ½” lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / ½” lugs, 4 psi)

S1 – 2006 Polaris Switchback 900 (144 x 15 x 1¼” track)

S2 – 2006 Polaris RMK 700 (144 x 15 x 2” track)

Individual Vehicle Observations

A1: 2005 Polaris Sportsman 700 ATV

Hill/curve pass-by – four uphill and downhill pass-bys were done at 30 to 40 mph/48 to 64 kph. Tire impressions were the most predominant in the 35 degree curve and near the crest of the hill. They were generally 3 to 5 cm (1.2 to 2 in) deep and 25 to 27 cm (9.8 to 10.6 in) wide. The operator described the vehicle as being “squirrely” when coming downhill.



Photo 77: Tire impressions on hill

A2: 2006 Polaris Predator 500 ATV

Hill/curve pass-by – four uphill and downhill pass-bys were done at 30 to 40 mph/48 to 64 kph. This vehicle was much more squirrely than the Sportsman ATV and struggled all the way up the hill. The vehicle’s tires also produced lots of snow spray. Tire impressions were prevalent through most all of the test area due to lots of tire spin. They were generally 4 to 5 cm (1.6 to 2 in) deep and 28 to 31 cm (11 to 12.2 in) wide, although one corner had 5 cm (2 in) deep by 45 cm (17.7 in) wide marks due to extreme sliding through the 35 degree curve. The operator described the vehicle as being “extremely squirrely.”



Photo 78: Tire impressions at curve

S1: 2006 Polaris Switchback 900 Snowmobile

Hill/curve pass-by – four uphill and downhill pass-bys were done at 45 to 55 mph/72 to 88 kph. Track marks throughout the test area were predominantly “surface chew” 2 cm (0.8 in) deep, with 2 to 4 cm (0.8 to 1.6 in) deep and 38 to 42 cm (15 to 16.5 in) wide track impressions in the 35 degrees curve.

S2: 2006 Polaris RMK 700 Snowmobile

Hill/curve pass-by – four uphill and downhill pass-bys were done at 50 to 60 mph/80 to 96 kph. Track marks throughout the test area were predominantly “surface chew” 3 cm (1.2 in) deep, along with 2 to 3 cm (0.8 to 1.2 in) deep ski skag marks. Track impressions in the 35 degrees curve were 3 to 4 cm (1.2 to 1.6 in) deep and 41 to 45 cm (16.1 to 17.7 in) wide. There was significant snow spray from the track during uphill acceleration.



Photo 79: Surface chew from snowmobile pass-bys

Summary of Observations from SD 5 Field Test

- **ATV OPERATION:** Passes by the ATVs generated tire tracks 3 to 5 cm (1.2 to 2 in) deep that were 25 to 31 cm (9.8 to 12.2 in) wide.

- **SNOWMOBILE OPERATION:** Passes by the snowmobiles generated track marks 2 to 4 cm (0.8 to 1.6 in) deep and 38 to 45 cm (15 to 17.7 in) wide.
- None of the vehicles created severe rutting of the trail surface. The snowmobiles were run after the two ATVs and their passes re-leveled the tire tracks left by the ATVs.
- The snowmobiles easily negotiated the hill and curves at relatively high rates of speed, while the ATVs were both squirrely and hard to control even though they were operated at speeds that were 15 to 20 mph/24 to 32 kph less than the snowmobiles.

**Field Testing Journal: January 26, 2006
South Pass, Wyoming (WY 1)**

Field Study Code/Number: WY 1

Location: CDA Trail at the CDA/Trail F junction; near Lander, Wyoming

Elevation: 8431 feet

Temperature Range: 24.7 F/-4.1 C (start) to 31.9 F/-0.1 C (end)

Time of Day: 9:38 AM to 11:56 AM

Weather: overcast, very flat light, 16 mph / 25.7 kph wind

Trail Aspect: the slow/normal and fast/aggressive tracks were flat; the hill/curve test area had a long straightaway that started at the junction and ended with a 16% grade and a 40 degrees corner/curve at the top of the hill. Both were on a wide, open gravel roadway.

Trail Conditions: groomed 30 to 36 hours prior to testing (groomed Tuesday night/early Wednesday morning and tested Thursday morning; slightly wind blown, very good compaction, very hard trail base

Compacted Snow Depth: 40 cm (15.7 in) to gravel; packed hard to the ground.

Uncompacted snow depth adjacent to the trail: 45.7 to 61 cm (20 to 24 inches)

Area Grooming Equipment: Tucker 2000 TERRA with Mogul Master 18-08 drag



Photo 80: Site of WY 1 field test

Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / 1/2” lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / 1/2” lugs, 4 psi)

S1 – 2006 Polaris Switchback 900 (144 x 15 x 1 1/4” track)

S2 – 2006 Polaris RMK 700 (144 x 15 x 2” track)

Individual Vehicle Observations

Note: Due to flat light conditions, it was difficult to get photos with good contrast from this field test.

A1: 2005 Polaris Sportsman 700 ATV

Slow/normal track – all starts, stops and 15 mph/24 kph pass-bys resulted in tire “surface chew” that was 2 cm (0.8 in) deep. Tire tracks were visible and consistent the entire length all zones.

Photo 81: Tire impressions from slow pass-by



Fast/aggressive track – starts resulted in tire tracks that were 2 to 5 cm (0.8 to 2 in) deep and 20 to 28 cm (7.9 to 11 in) wide. The 35 mph/56 kph pass-bys resulted in visible tire tracks 2 cm (0.8 in) deep and 25 to 28 cm (9.8 to 11 in) wide and left no visible trenching or rutting. Stops resulted in

tire impressions that were 2 to 4 cm (0.8 to 1.6 in) deep and 20 to 25 cm (7.9 to 9.8 in) wide. Stopping distance at 35 mph/56 kph ranged from 18.3 to 25.0 meters (60.1 to 82.0 feet), with an average stopping distance of 21.1 meters (69.2 feet).

16% Hill/40 degree corner pass-by – the maximum uphill speed that could be attained was 30 mph/48 kph, while downhill speed was 40 mph/64 kph. The operator described the vehicle’s operation as “squirrely” on all passes. Tire impressions were 2 to 4 cm (0.8 to 1.6 in) deep and 20 to 26 cm (7.9 to 11 in) wide.

A2: 2006 Polaris Predator 500 ATV

Slow/normal track – all starts, stops and 15 mph/24 kph pass-bys resulted in tire “surface chew” that was 1.5 cm (0.6 in) deep and 25 cm (9.8 in) wide. Tire tracks were visible and consistent the entire length all zones.

Fast/aggressive track – starts resulted in tire tracks that were 3 to 8 cm (1.2 to 3.1 in) deep and 25 to 29 cm (9.8 to 11.4 in) wide. The 35 mph/56 kph pass-bys resulted in visible tire tracks 3 cm (1.2 in) deep and 28 cm (11 in) wide and left no visible trenching or rutting. Stops resulted in tire impressions that were 3 to 4 cm (1.2 to 1.6 in) deep and 28 cm (11 in) wide. Stopping distance at 35 mph/56 kph ranged from 17.4 to 27.7 meters (57.2 to 91.0 feet), with an average stopping distance of 23.2 meters (76.0 feet).

16% Hill/40 degree corner pass-by – the maximum uphill and downhill speed was estimated at 55 to 60 mph/88 to 96 kph through the straightaway and into and out of the bottom side of the curve. The operator described the vehicle’s operation as “it felt out of control from start to finish at all speeds.” Tire impressions were generally 5 cm (2 in) deep and 25 cm (9.8 in) wide on the hill and in the curve.

S1: 2006 Polaris Switchback 900 Snowmobile

Slow/normal track – all starts, stops and 15 mph/24 kph pass-bys resulted in 1 cm (0.4 in) deep grooves from the ski skags and “surface chew” from the track that was also 1 cm (0.4 in) deep. The skag marks and surface chew were visible and consistent the entire length of the start, pass-by, and stop zones.

Fast/aggressive track – starts resulted in track marks that were 2.5 to 5 cm (1 to 2 in) deep and 39 cm (15.4 in) wide. The 35 mph/56 kph pass-bys resulted in “surface chew” from the track that was 2 cm (0.8 in) deep and 38 to 39 cm (15 to 15.4 in) wide. There was no visible trenching or rutting of the trail. Stops resulted in track impressions that were generally 5 cm (2 in) deep and 42 cm (16.5 in) wide. Stopping distance at 35 mph/56 kph ranged from 24.3 to 30.4 meters (79.8 to 99.9 feet), with an average stopping distance of 27.4 meters (89.9 feet).



Photo 82: Surface chew & skag mark from slow pass-by

16% Hill/40 degree corner pass-by – this vehicle was not tested on the hill/curve since the RMK snowmobile with its aggressive track was chosen for “worst-case” comparison purposes.

S2: 2006 Polaris RMK 700 Snowmobile

Slow/normal track – all starts, stops and 15 mph/24 kph pass-bys resulted in 1 cm (0.4 in) deep grooves from the ski skags and “surface chew” from the track that was 2 cm (0.8 in) deep. The skag marks and surface chew were visible and consistent the entire length of the start, pass-by, and stop zones.

Fast/aggressive track – starts resulted in track marks that were 3 to 4 cm (1.2 to 1.6 in) deep and 38 cm (15 in) wide. The 35 mph/56 kph pass-bys resulted in surface chew from the track that was 2 to 4 cm (0.8 to 1.6 in) deep and 39 to 41 cm (15.4 to 16.1 in) wide. There was no visible trenching or rutting of the trail. Stops resulted in track impressions that were 3 to 4 cm (1.2 to 1.6 in) deep and 38 to 41 cm (15 to 16.1 in) wide. Stopping distance at 35 mph/56 kph ranged from 20.6 to 28.3 meters (67.6 to 92.9 feet), with an average stopping distance of 24.6 meters (80.8 feet).

16% Hill/40 degree corner pass-by – the maximum uphill and downhill speed was 60 to 70 mph/96 to 113 kph through the straightaway and into and out of the bottom side of the curve. Track marks were generally 5 cm (2 in) deep surface chew on the hill and in the curve.

Summary of Observations from WY 1 Field Test

- **SLOW/NORMAL OPERATION:** None of the vehicles created noticeable adverse impacts when operated in the slow/normal mode whether in the start, 15 mph/24 kph pass-by, or stop zones.
- **FAST/AGGRESSIVE PASS-BY:** None of the vehicles created noticeable adverse impacts when operated in the 35 mph/56 kph pass-by mode.
- **AGGRESSIVE STARTS:** ATVs created slightly deeper tracks in the trail than what the snowmobiles did. Aggressive starts resulted in ATV tire tracks 2 to 8 cm (0.8 to 3.1 in) deep and 25 to 29 cm (9.8 to 11.4 in) wide. Snowmobile track impressions were 2.5 to 5 cm (1 to 2 in) deep and 38 to 41 cm (15 to 16.1 in) wide. The deepest tire tracks from the Predator ATV were 3 cm (1.2 in) deeper than the deepest snowmobile track impressions.
- **AGGRESSIVE STOPS:** Snowmobiles created slightly deeper tracks in the trail than what the ATVs did. Aggressive stops resulted in ATV tire tracks 2 to 4 cm (0.8 to 1.8 in) deep and 20 to 28 cm (7.9 to 11 in) wide. Snowmobile track impressions were 3 to 5 cm (1.2 to 2 in) deep and 39 to 42 cm (15.4 to 16.5 in) wide. The deepest snowmobile track impressions from the Switchback snowmobile were 1 cm (0.4 in) deeper than the deepest ATV tire tracks.
- **STOPPING DISTANCE – CONTROL VEHICLES:** The two ATVs generally stopped in a shorter distance than what the two snowmobiles did. The Sportsman ATV had the shortest average stopping distance, while the Switchback snowmobile had the longest average stopping distance. The average ATV stopping distances at 35 mph/56 kph ranged from 21.1 to 23.2 meters (69.2 to 76.0 feet), while the average snowmobile stopping distance ranged from 24.6 to 27.4 meters (80.8 to 89.9 feet). The minimum average ATV stopping distance (the Sportsman ATV) was 3.5 meters/11.5 feet (14.2%) less than the shortest average snowmobile stopping distance, while the maximum average snowmobile stopping distance (the Switchback snowmobile) was 4.2 meters/13.8 feet (18.1%) greater than longest average ATV stopping distance.
- **HILL/CURVE PASS-BYS:** These pass-bys were run at top speeds to observe the difference in operational characteristics between the vehicles, as well as to observe the effects upon the trail surface. The RMK snowmobile was able to stay “under control” up the hill and through the curve, while both ATVs were judged as “very squirrely” by the operator and the 2-wheel drive Predator deemed “pretty much out of control.” By comparison, the snowmobile remained much more in control through the curve despite being operated at speeds that were 10 to 40 mph/16 to 64 kph faster than the ATVs. Tire tracks on the hill and in the curve from the Sportsman ATV were 2 to 4 cm (0.8 to 1.6 in) deep, while tire impressions from the Predator ATV and track marks from the RMK snowmobile were both 5 cm (2 in) deep.

**Field Testing Journal: January 26, 2006
South Pass, Wyoming (WY 2)**

Field Study Code/Number: WY 2
Location: F Trail at the CDA Trail/Trail F junction; near Lander, Wyoming
Elevation: 8431 feet
Temperature Range: 29.3 F/-1.5 C (start) to 27.2 F/-2.7 C (end)
Time of Day: 2:24 PM to 3:05 PM
Weather: sunny, clear, 12 mph/19 kph wind
Trail Aspect: flat, open meadow
Trail Conditions: smooth and in good condition; had been groomed one week prior. While the trail appeared to be in good condition, it quickly deteriorated after only eight runs on it by ATVs.



Photo 83: Site of WY 2 field test

Further investigation determined that this particular trail segment had a different grooming schedule and different grooming equipment than the CDA Trail immediately adjacent to it (location of WY 1 test). Whereas the CDA Trail had been groomed multiple times weekly for several weeks with a multi-blade drag, this particular trail had been groomed only three times over the previous six week period (and only three times the entire season) and with a single blade drag rather than with a multi-blade drag.

Compacted Snow Depth: 30 cm (11.8 in) to grass, but only the top 10 cm (3.9 in) was compacted while the bottom 20 cm (7.9 in) was loose and sugary

Uncompacted snow depth adjacent to the trail: 35.5 to 45.7 cm (14 to 18 inches)

Area Grooming Equipment: Tucker 2000 TERRA with Freese 8-foot wide single blade drag

Control Vehicles

None, they were run on the WY 1 location which is directly adjacent to this location – this new location was used to give the “Other” vehicles a fresh test track

Other Vehicles

A3 – 2005 Bombardier Traxter XL 500 (4x4; auto/manual transmission; 26 x 10-12 rear tires / ½” lugs, 7 psi)

A4 – 2003 Polaris Sportsman 500 6x6 (6x6; auto transmission; 25 x 11-10 rear tires / ½” lugs, 5 psi)

Individual Vehicle Observations

A3: 2005 Bombardier Traxter 500 ATV

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in tire tracks that were 4 to 5 cm (1.6 to 2 in) deep and 20 to 21 cm (7.9 to 8.3 in) wide. The pass-bys at 35 mph/56 kph left visible tire tracks 2 cm (0.8) deep but no trenching or rutting of the trail surface. Stops resulted in tire impressions that were 2 cm {1st pass only} to 10 cm (0.8 to 3.9 in) deep and 21 to 30 cm (8.3 to 11.8 in) wide. Stopping distance at 35 mph/56 kph ranged from 13.3 to 16.9 meters (43.6 to 55.4 feet), with an average stopping distance of 14.7 meters (48.1 feet). The trail base quickly became soft and rutted in the start and stop zones.



Photo 84: Impressions from an aggressive start



Photo 85: Impressions from an aggressive stop

A4: 2003 Polaris Sportsman 500 6X6 ATV

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in tire tracks that were 2 to 3 cm (0.8 to 1.2 in) deep and 24 cm (9.5 in) wide. The pass-bys at 35 mph/56 kph left visible tire tracks 2 cm (0.8) deep and 19 cm (7.5 in) wide, but no trenching or rutting of the trail surface. Stops resulted in tire impressions that were 5 to 8 cm (2 to 3.1 in) deep and 26 cm (10.2 in) wide. Stopping distance at 35 mph/56 kph ranged from 11.0 to 16.5 meters (36.1 to 54.0

feet), with an average stopping distance of 12.8 meters (42.1 feet). The trail base quickly became soft and rutted in the start and stop zones.



Photo 86: Impressions from an aggressive start

Photo 87: Impressions from an aggressive stop

Summary of Observations from WY 2 Field Test

- FAST/AGGRESSIVE PASS-BY: Neither of the vehicles created noticeable adverse impacts when operated in the 35 mph/56 kph pass-by mode, just normal surface chew.
- AGGRESSIVE STARTS: Starts resulted in ATV tire impressions that were 2 to 5 cm (0.8 to 2 in) deep and 20 to 24 cm (7.9 to 9.5 in) wide. While the 6X6 ATV was substantially heavier than the other ATV, its tire impressions were less, most likely due to its weight being distributed over six tires versus four on the other ATV.
- AGGRESSIVE STOPS: Stops resulted in ATV tire impressions 2 to 10 cm (0.8 to 3.9 in) deep and 21 to 30 cm (8.3 to 11.8 in) wide. Stops at both ends of the track quickly began breaking through the compacted surface which was only 10 cm (3.9 in) thick.
- STOPPING DISTANCE – OTHER VEHICLES: The two ATVs generally stopped in a relatively short distance compared to the vehicle stopping distances in other tests. This was most likely due to the less densely compacted trail that quickly led to soft trail conditions after just a few passes by the ATVs. The 6X6 ATV stopped very quickly due to its heavier weight and six wheels braking.
- Due to the quick deterioration of the trail after just eight vehicle passes, the decision was made to relocate the test track back onto the CDA Trail, and to rerun these two vehicles on the firmer CDA Trail surface.
- Even though this testing was done on January 26, this trail segment is likely a good indicator of early season trail compaction given that it had been groomed only a total of three times (snow came late so grooming started late). It may also serve as an indicator that trails groomed with single blade drags may not have enough compaction to withstand ATV traffic.



Photo 88: Poorly compacted trail – note hollow pocket 4” down



Photo 89: A well compacted trail from Site SD 4

Field Testing Journal: January 26, 2006

South Pass, Wyoming (WY 3)

Field Study Code/Number: WY 3

Location: CDA Trail approximately 1.5 miles west of the Trail F junction; near Lander, Wyoming

Elevation: 8509 feet

Temperature Range: 29.3 F/-1.5 C (start) to 25.9 F/-3.4 C (end)

Time of Day: 3:23 PM to 4:12 PM

Weather: sunny, clear, 8 mph/12.8 kph wind

Trail Aspect: on a flat, open roadway

Trail Conditions: smooth and in good condition; was groomed 30 to 36 hours prior to testing (groomed Tuesday night/early Wednesday morning and tested Thursday morning; slightly wind blown, very good compaction, very hard trail base

Compacted Snow Depth: 46 cm (18.1 in) to gravel, packed hard to the ground

Uncompacted snow depth adjacent to the trail: 45.7 to 61cm (20 to 24 inches)

Area Grooming Equipment: Tucker 2000 TERRA with Mogul Master 18-08 drag



Photo 90: Site of WY 3 field test

Control Vehicles

None – they were run at the WY 1 location

Other Vehicles

A3 – 2005 Bombardier Traxter XL 500 (4x4; auto/manual transmission; 26 x 10-12 rear tires / ½” lugs, 7 psi)

A4 – 2003 Polaris Sportsman 500 6x6 (6x6; auto transmission; 25 x 11-10 rear tires / ½” lugs, 5 psi)

A5 – 2002 Yamaha Kodiak 400 (4x4; auto transmission; 25 x 10-12 rear tires / ⅜” lugs, 4 psi)

S3 – 2004 Arctic Cat Turbo Touring T660 4-stroke (136 x 15 x ¾” track)

Individual Vehicle Observations

A3: 2005 Bombardier Traxter 500 ATV

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in tire tracks that were 2 cm (0.8 in) deep and 21 cm (8.3 in) wide. In comparison, tire tracks from the same vehicle when it was run at site WY 2 (a less firm trail base) were 4 to 5 cm (1.6 to 2 in) deep and 20 to 21 cm (7.9 to 8.31 in) wide. The pass-bys resulted in tire tracks 2 cm (0.8 in) deep and 26 cm (10.2 in) wide, compared to site WY 2 which were also 2 cm (0.8 in) deep. There was no visible



Photo 91: Impressions from an aggressive start



Photo 92: An aggressive stop

trenching or rutting of the trail surface from the pass-bys. Stops resulted in tire impressions that were 2 to 3 cm (0.8 to 1.2 in) deep and 21 to 30 cm (8.3 to 11.8 in) wide, compared to 8 to 10 cm (3.1 to 3.9 in) deep and 21 to 30 cm (8.3 to 11.8 in) wide tire impressions at site WY 2. Stopping distance at 35 mph/56 kph ranged from 13.0 to 21.1 meters (42.7 to 69.3 feet), with an average stopping distance of 17.1 meters (56.2 feet). This compared to a range of 13.3 to 16.9 meters (43.6 to 55.4 feet) and an average stopping distance of 14.7 meters (48.1 feet) at site WY 2.

A4: 2003 Polaris Sportsman 500 6X6 ATV

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in tire tracks that were 2 to 3 cm (0.8 to 1.2 in) deep and 18 to 21 cm (7.1 to 8.3 in) wide. In comparison, tire tracks from the same vehicle when it was run at site WY 2 (a less firm trail base) were also 2 to 3 cm (0.8 to 1.2 in) deep but were 24 cm (9.5 in) wide. The pass-bys resulted in tire tracks 2 cm (0.8 in) deep and 19 cm (7.5 in) wide, which were the same results from the vehicle at the WY 2 pass-by site. There was no visible trenching or rutting of the trail surface from the pass-bys. Stops resulted in tire impressions that were 2 to 4 cm (0.8 to 1.6 in) deep and 18 to 27 cm (7.1 to 10.6 in) wide, compared to 5 to 8 cm (2 to 3.1 in) deep and 26 cm (10.2 in) wide tire impressions at site WY 2.



Photo 93: Tire impressions from an aggressive stop

Stopping distance at 35 mph/56 kph ranged from 14.3 to 19.3 meters (46.9 to 63.3 feet), with an average stopping distance of 16.9 meters (55.3 feet). This compared to a range of 11.0 to 16.5 meters (36.1 to 54.0 feet) and an average stopping distance of 12.8 meters (42.1 feet) at site WY 2.

A5: 2002 Yamaha Kodiak 400 ATV

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in tire tracks that were 2 cm (0.8 in) deep and 20 cm (7.9 in) wide. The pass-bys resulted in surface chew from the tire treads that was 2 cm (0.8 in) deep. There was no trenching or rutting of the trail surface. Stops resulted in tire impressions that were 2 to 4 cm (0.8 to 1.6 in) deep and 20 to 30 cm (7.9 to 11.8 in) wide. Stopping distance at 35 mph/56 kph ranged from 14.3 to 20.9 meters (46.9 to 68.5 feet), with an average stopping distance of 18.2 meters (59.7 feet).



Photo 94: An aggressive start



Photo 95: Tire impressions from an aggressive stop

S3: 2004 Arctic Cat Turbo Touring T660 4-stroke Snowmobile

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in track impressions that were 1 to 2 cm (0.4 to 0.8 in) deep. The pass-bys resulted in surface chew from the track that was 1 cm (0.4 in) deep. There was no trenching or rutting of the trail surface. Stops resulted in track marks that were 1 to 2 cm (0.4 to 0.8 in) deep and 36 cm (14.2 in) wide due to the vehicle sliding sideways during the stop. Stopping distance at 35 mph/56 kph ranged from 13.7 to 26.1 meters (45.0 to 85.7 feet), with an average stopping distance of 19.9 meters (65.3 feet). One reason for the wide variation in stopping distance was that one end of the track was icier and the vehicle's shorter track lugs allowed it to slide easily on the smooth trail surface.



Photo 96: Impression from an aggressive stop

Summary of Observations from WY 3 Field Test

- **FAST/AGGRESSIVE PASS-BYS:** None of the vehicles created noticeable adverse impacts when operated in the 35 mph/56 kph pass-by mode, just normal surface chew.
- **AGGRESSIVE STARTS:** ATVs created slightly deeper tracks in the trail than what the snowmobile did. Starts resulted in ATV tire impressions that were 2 to 3 cm (0.8 to 1.2 in) deep and 18 to 21 cm (7.1 to 8.3 in) wide. By comparison, snowmobile track impressions from the Arctic Cat snowmobile were 1 to 2 cm (0.4 to 0.8 in) deep.
- **AGGRESSIVE STOPS:** ATVs created slightly deeper tracks in the trail than what the snowmobile did. Stops resulted in ATV tire impressions 2 to 4 cm (0.8 to 1.6 in) deep and 18 to 30 cm (7.1 to 11.8 in) wide. By comparison, snowmobile track impressions from the Arctic Cat snowmobile were 1 to 2 cm (0.4 to 0.8 in) deep and 36 cm (14.2 in) wide.
- **STOPPING DISTANCE – OTHER VEHICLES:** The ATVs generally stopped in a shorter distance than what the snowmobile did. The Sportsman 6x6 ATV had the shortest average stopping distance, while the Arctic Cat snowmobile had the longest average stopping distance at this location. The average ATV stopping distances at 35 mph/56 kph ranged from 16.9 to 18.2 meters (55.3 to 59.7 feet), while the average snowmobile stopping distance was 19.9 meters (65.3 feet). The minimum average ATV stopping distance (the Sportsman 6x6 ATV) was 3.0 meters/9.8 feet (15.1%) less than the shortest average snowmobile stopping distance, while the average snowmobile stopping distance for the Arctic Cat snowmobile was 1.7 meters/5.6 feet (9.3%) greater than longest average ATV stopping distance.

Comparison of All Vehicles (Control and Other Vehicles) from WY 1 and WY 3 Field Tests

The four 'control' vehicles were tested at site WY 1, while four 'other' vehicles were tested at site WY 3. Both sites had nearly identical conditions so the results of the start, pass-by, and stop tests are comparable.

- **FAST/AGGRESSIVE PASS-BY:** None of the vehicles created noticeable adverse impacts when operated in the 35 mph/56 kph pass-by mode.
- **AGGRESSIVE STARTS:** ATVs created slightly deeper tracks in the trail than what the snowmobiles did. Aggressive starts resulted in ATV tire tracks 2 to 8 cm (0.8 to 3.1 in) deep and 18 to 29 cm (7.1 to 11.4 in) wide. Snowmobile track impressions were 1 to 5 cm (0.4 to 2 in) deep and 38 to 41 cm (15 to 16.1 in) wide. The deepest tire tracks were from the Predator ATV and were 3 cm (1.2 in) deeper than the deepest snowmobile track impressions which were from the Switchback snowmobile.
- **AGGRESSIVE STOPS:** Snowmobiles created slightly deeper tracks in the trail than what the ATVs did. Aggressive stops resulted in ATV tire tracks 2 to 4 cm (0.8 to 1.8 in) deep and 18 to 30 cm (7.1 to 11.8 in) wide. Snowmobile track impressions were 1 to 5 cm (0.4 to 2 in) deep and 36 to 42 cm (14.2 to 16.5 in) wide. The deepest snowmobile track impressions were from the Switchback snowmobile and were 1 cm (0.4

in) deeper than the deepest ATV tire tracks left by four of the five ATVs that were tested and 2 cm (0.8 in) deeper than the Bombardier Traxter's deepest tire impressions.

- **STOPPING DISTANCE – ALL VEHICLES:** The four 'other' vehicles (three ATVs and one snowmobile) all had a shorter average stopping distance than what the four 'control' vehicles (two ATVs and two snowmobiles) did. All ATVs generally stopped in a shorter distance than what the two control snowmobiles did, while the Arctic Cat snowmobile stopped in a shorter distance than what the two control ATVs did. The Sportsman 6x6 ATV had the shortest average stopping distance of all vehicles, while the Switchback snowmobile had the longest average stopping distance of all vehicles. The average ATV stopping distances at 35 mph/56 kph ranged from 16.9 to 23.2 meters (55.3 to 76.0 feet), while the average snowmobile stopping distance ranged from 19.9 to 27.4 meters (65.3 to 89.9 feet). The minimum average ATV stopping distance (the Sportsman 6x6 ATV) was 3.0 meters/9.8 feet (15.1%) less than the shortest average snowmobile stopping distance, while the maximum average snowmobile stopping distance (the Switchback snowmobile) was 4.2 meters/13.8 feet (18.1%) greater than longest average ATV stopping distance.

**Field Testing Journal: February 8, 2006
Iron River, Wisconsin (WI 1)**

Field Study Code/Number: WI 1

Location: State Corridor Trail 2/4 3 miles east of Iron River, Wisconsin

Elevation: 1336 feet

Temperature Range: 11.0 F/-11.7 C (start) to 24.6 F/-4.1 C (end)

Time of Day: 8:55 AM to 11:36 AM

Weather: clear, calm

Trail Aspect: flat, located on railroad grade trail corridor

Trail Conditions: hard packed and very slight surface wear from traffic; last groomed the prior day (approx.16 hours prior) and was in good condition

even though there had been lots of snowmobile traffic on the trail

Compacted Snow Depth: 24 cm (9.45 in) – packed very hard to the ground, some layers of ice.

Uncompacted snow depth adjacent to the trail: 30 to 46 cm (12 to 18 in)

Area Grooming Equipment: New Holland tractor with Lacrosse drag



Photo 97: Site of WI 1 field test

Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / 1/2" lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / 1/2" lugs, 4 psi)

S1 – 2006 Polaris Switchback 900 (144 x 15 x 1 1/4" track)

S2 – 2006 Polaris RMK 700 (144 x 15 x 2" track)

Other Vehicles

A3 – 2005 Kawasaki Brute Force 750 (4x4; auto transmission; 25 x 10-12 rear tires / 1/2" lugs, 6 psi)

A4 – 1999 Honda Foreman ES 450 (4x4; auto transmission; 25 x 10-12 rear tires / 3/8" lugs, 2 psi)

S3 – 2002 Yamaha Viper 700 (121 x 15 x 3/4" track)

S4 – 2004 Arctic Cat Bearcat 660 4-stroke (141 x 19.5 x 1" track)

Individual Vehicle Observations

A1: 2005 Polaris Sportsman 700 ATV

Slow/normal track – generally, all starts, stops, and 15 mph/24 kph pass-bys resulted in visible tire tread tracks consistent with tire lug depth and width that were consistently 1 cm (0.4 in) deep and 19 cm (7.5 in) wide. Tire tracks were generally visible, consistent and the same the entire length of the start and pass-by zones. The stops resulted in tire impressions 2 cm (0.8 in) deep and 22 cm (8.7 in) wide.



Photo 98: Surface chew from a slow pass-by

Fast/aggressive track – starts resulted in tire tracks that varied from 2 to 3 cm (0.8 to 1.2 in) deep and 22 to 24 cm (8.7 to 9.5 in) wide. The fast pass-bys resulted in visible tire tracks 1 to 2 cm (0.4 to 0.8 in.) deep and 18 to 21 cm (7.1 to 8.3 in) wide and left no visible trenching or rutting. Stops resulted in tire impressions that varied from 2 to 3 cm (0.8 to 1.2 in) deep and 26 to 30 cm (10.2 to 11.8 in) wide. Stopping distance at 35 mph/56 kph ranged from 12.8 to 17.8 meters (42 to 58.3 feet), with an average stopping distance of 14.9 meters (49 feet).



Photo 99: Impressions from an aggressive start



Photo 100: Impressions from an aggressive stop

A2: 2006 Polaris Predator 500 ATV

Slow/normal track – generally, all starts, stops and 15 mph/24 kph pass-bys resulted in visible tire tread tracks consistent with tire lug depth and width that were consistently 1.5 cm (0.6 in) deep and 27 to 30 cm (10.6 to 11.8 in) wide. Tire tracks were generally visible, consistent and the same the entire length of the start and pass-by zones. The stops resulted in tire impressions 1.5 cm (0.6 in) deep and 27 cm (10.6 in) wide.



Photo 101: Surface chew from a slow pass-by

Fast/aggressive track – starts resulted in tire tracks that varied from 5 to 6 cm (2 to 2.4 in) deep and 28 to 30 cm (11 to 11.8 in) wide. The fast pass-bys resulted in visible tire tracks 2 to 3 cm (0.8 to 1.2 in.) deep and 28 to 30 cm (11 to 11.8 in) wide and left no visible trenching or rutting. Stops resulted in tire impressions that varied

from 2 to 4 cm (0.8 to 1.6 in) deep and 30 to 46 cm (10.8 to 18.1 in) wide. Stopping distance at 35 mph/56 kph ranged from 10.5 to 12.0 meters (34.4 to 39.5 feet), with an average stopping distance of 11.4 meters (37.4 feet).



Photo 102: Impressions from an aggressive start



Photo 103: Impressions from an aggressive stop

A3: 2005 Kawasaki Brute Force 750 ATV

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in tire tracks that varied from 4 to 8 cm (1.6 to 3.1 in) deep and 24 to 28 cm (9.5 to 11 in) wide. The fast pass-bys resulted in visible tire tracks 2 cm (0.8) deep and 24 to 26 cm (9.5 to 10.2 in) wide and left no visible trenching or rutting. Stops resulted in tire impressions that varied from 3 to 5 cm (1.2 to 2 in) deep and 20 to 24 cm (7.9 to 9.5 in) wide. Stopping distance at 35 mph/56 kph ranged from 15 to 18 meters (49.3 to 58.9 feet), with an average stopping distance of 16.1 meters (52.8 feet).



Photo 104: Impressions from an aggressive start



Photo 105: Impressions from an aggressive stop

A4: 1999 Honda Foreman ES 450 ATV

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in tire tracks that varied from 2 to 2.5 cm (0.8 to 1 in) deep and 27 to 28 cm (10.6 to 11 in) wide. The fast pass-bys resulted in visible tire tracks 1.5 to 2 cm (0.6 to 0.8) deep and 27 to 28 cm (10.6 to 11 in) wide and left no visible trenching or rutting. Stops resulted in tire impressions that varied from 2 to 2.5 cm (0.8 to 1 in) deep and 25 to 26 cm (9.8 to 10.2 in) wide. Stopping distance at 35 mph/56 kph ranged from 12.9 to 15.2 meters (42.3 to 49.8 feet), with an average stopping distance of 13.7 meters (45.1 feet).



Photo 106: Impressions from an aggressive start



Photo 107: Impressions from an aggressive stop

S1: 2006 Polaris Switchback 900 Snowmobile
Slow/normal track – generally, all starts, stops, and 15 mph/24 kph pass-bys resulted in visible grooves from the ski skags that were 2.5 cm (1 in) deep and 6 cm (2.4 in) wide. “Surface chew” from the track was 1.5 to 2 cm (0.6 to 0.8 in) deep and 38 cm (15 in) wide. The skag marks and surface chew were generally consistently visible and the same the entire length of the start, pass-by, and stop zones consistent with trail wear from normal snowmobile traffic.



Photo 108: Surface chew and skag marks from slow pass-by

Fast/aggressive track – starts resulted in track marks that were 5 to 6 cm (2 to 2.4 in) deep and 40 cm (15.7 in) wide. The 35 mph/56 kph pass-bys resulted only in normal surface chew from the track that was 3 cm (1.2 in) deep and 38 to 40 cm (15 to 15.7 in) wide. There was no visible trenching or rutting other than the 2.5 cm (1 in) deep and 6 cm (2.4 in) wide ski skag grooves that were visible throughout all three zones. Stops resulted in trail surface impressions that were 2 to 5 cm (0.8 to 2 in) deep and 40 to 42 cm (15.7 to 16.5 in) wide. Stopping distance at 35 mph/56 kph ranged from 19.3 to 21.1 meters (63.3 to 69.3 feet), with an average stopping distance of 20.6 meters (67.5 feet).



Photo 109: Impression from an aggressive start



Photo 110: Impression from an aggressive stop

S2: 2006 Polaris RMK 700 Snowmobile

Slow/normal track – generally, all starts, stops and 15 mph/24 kph pass-bys resulted in visible grooves from the ski skags that were 2 cm (0.8 in) deep and 5 cm (2 in) wide. “Surface chew” from the track was 2 cm (0.8 in) deep and 38 cm (15 in) wide. The skag marks and surface chew were generally consistently visible and the same the entire length of the start, pass-by, and stop zones consistent with trail wear from normal snowmobile traffic. Track impressions in the stop zone were 3 cm (1.2 in) deep and 38 cm (15 in) wide.



Photo 111: Surface chew and skag marks from a slow pass

Fast/aggressive track – starts resulted in track marks that were 3 to 5 cm (1.2 to 2 in) deep and 38 to 40 cm (15 to 15.7 in) wide. The 35 mph/56 kph pass-bys resulted only in normal surface chew from the track that was 2.5 to 3 cm (1 to 1.2 in) deep and 38 to 40 cm (15 to 15.7 in) wide.

There was no visible trenching or rutting other than the 2 cm (0.8 in) deep and 5 cm (2 in) wide ski skag grooves that were visible throughout all three zones. Stops resulted in trail surface impressions that were 3 to 5 cm (1.2 to 2 in) deep and 40 to 45 cm (15.7 to 17.7 in) wide. Stopping distance at 35 mph/56 kph ranged from 16.1 to 21.1 meters (52.8 to 69.3 feet), with an average stopping distance of 18.5 meters (60.8 feet).



Photo 112: Impression from an aggressive start



Photo 113: Impression from an aggressive stop

S3: 2002 Yamaha Viper 700 Snowmobile

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in track marks that were 2 to 4 cm (0.8 to 1.6 in) deep and 42 to 43 cm (16.5 to 16.9 in) wide. The 35 mph/56 kph pass-bys resulted in surface chew from the track that was 1.5 to 2 cm (0.6 to 0.8 in) deep and 38 to 40 cm (15 to 15.7 in) wide. There was no visible trenching or rutting. 2 cm (0.8 in) deep and 5 cm (2 in) wide ski skag grooves were visible throughout all three zones. Stops resulted in trail surface impressions that were 2 to 3 cm (0.8 to 1.2 in) deep and 45 to 47 cm (17.7 to 18.5 in) wide. Stopping distance at 35 mph/56 kph ranged from 19.9 to 24.6 meters (65.3 to 80.8 feet), with an average stopping distance of 22.4 meters (73.5 feet).



Photo 114: Impression from an aggressive start



Photo 115: Impression from an aggressive stop

S4: 2004 Arctic Cat Bearcat 660 4-stroke Snowmobile

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in track marks that were 4 to 5 cm (1.6 to 2 in) deep and 52 cm (20.5 in) wide. The 35 mph/56 kph pass-bys resulted in surface chew from the track that was 2 to 2.5 cm (0.8 to 1 in) deep and 52 cm (20.5 in) wide. Stops resulted in trail surface impressions that were 2 to 5 cm (0.8 to 2 in) deep and 52 cm (20.5 in) wide. Stopping distance at 35 mph/56 kph ranged from 21 to 23.4 meters (68.8 to 76.8 feet), with an average stopping distance of 22.6 meters (74.2 feet).



Photo 116: Impression from an aggressive start



Photo 117: Impression from an aggressive stop

Summary of Observations from the WI 1 Field Test

- **SLOW/NORMAL OPERATION:** None of the vehicles created noticeable adverse impacts when operated in the slow/normal mode whether in the start, 15 mph/24 kph pass-by, or stop zones.
- **FAST/AGGRESSIVE PASS-BY:** None of the vehicles created noticeable adverse impacts when operated in the 35 mph/56 kph pass-by mode.
- **AGGRESSIVE STARTS:** ATVs created slightly deeper impressions in the trail than what snowmobiles did. Aggressive starts resulted in ATV tire impressions 2 to 8 cm (0.8 to 3.1 in.) deep and 22 to 30 cm (8.7 to 11.8 in.) wide. Snowmobile track impressions were 2 to 6 cm (0.8 to 2.4 in.) deep and 38 to 52 cm (15 to 20.5 in.) wide. The deepest ATV tire tracks from were only slightly deeper (1 cm / 0.4 in) than the deepest snowmobile track impressions.
- **AGGRESSIVE STOPS:** There was no difference between the impressions created by ATVs and snowmobiles. Aggressive stops resulted in ATV tire impressions 2 to 5 cm (0.8 to 2 in.) deep and 20 to 30

cm (7.9 to 11.8 in.) wide. Snowmobile track impressions were 2 to 5 cm (0.8 to 2 in.) deep and 40 to 52 cm (15.7 to 20.5 in.) wide. The deepest ATV tire tracks and snowmobile track impressions were exactly the same.

- **STOPPING DISTANCE – ALL VEHICLES:** When comparing all vehicles tested, the ATVs generally stopped quicker than the snowmobiles. The Predator stopped the quickest of the four ATVs and the RMK stopped the quickest of the four snowmobiles. The Kawasaki Brute required the greatest distance to stop of the four ATVs, while the Bearcat required the greatest distance to stop of the four snowmobiles. The average ATV stopping distances at 35 mph/56 kph ranged from 11.4 to 16.1 meters (37.4 to 52.8 feet). The average snowmobile stopping distance ranged from 18.5 to 22.6 meters (60.8 to 74.2 feet). The minimum average ATV stopping distance (the Predator) was 7.1 meters/23.3 feet (62.3%) less than the shortest average snowmobile stopping distance, while the maximum average snowmobile stopping distance (the Bearcat) was 6.5 meters / 21.3 feet (40.4%) greater than the longest average ATV stopping distance.
- **STOPPING DISTANCE – CONTROL VEHICLES:** When comparing just the four control vehicles, the ATVs generally stopped quicker than the snowmobiles. The Predator stopped quicker of the two control ATVs, while the Switchback required the greatest distance to stop of the two control snowmobiles. The average ATV stopping distances at 35 mph/56 kph ranged from 11.4 to 14.9 meters (37.4 to 49 feet), while the average snowmobile stopping distance ranged from 18.5 to 20.6 meters (60.8 to 67.5 feet). The minimum average ATV stopping distance (the Predator) was 7.1 meters/23.3 feet (38.4%) less than the shortest average snowmobile stopping distance, while the maximum average snowmobile stopping distance (the Switchback) was 5.7 meters/8.7 feet (38.3%) greater than the longest average ATV stopping distance.

**Field Testing Journal: February 8, 2006
Iron River, Wisconsin (WI 2)**

Field Study Code/Number: WI 2

Location: State Corridor Trail 31 approx. 3 miles northeast of Iron River, Wisconsin

Elevation: 1336 feet

Temperature Range: 25.9 F/-3.4 C

Time of Day: 1:45 PM to 2:25 PM

Weather: clear, calm

Trail Aspect: trail located in borrow ditch along plowed roadway; approx. ¼ mile / 0.4 km long segment with 15% grade on each end with a valley in the middle of the two hills

Trail Conditions: hard packed and very slight surface wear from traffic; last groomed the prior day (approximately 16 hours prior) and was in good condition even though there had been lots of snowmobile traffic on the trail

Compacted Snow Depth: 9 cm (3.5 in) to ice layer in middle of the trail; 13 cm (5.1 in) to ground along edges of groomed trail – trail surface was generally packed very hard

Uncompacted snow depth adjacent to the trail: 30 to 46 cm (12 to 18 in)

Area Grooming Equipment: New Holland tractor with Lacrosse drag



Photo 118: Site of WI 2 testing

Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / ½” lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / ½” lugs, 4 psi)

S1 – 2006 Polaris Switchback 900 (144 x 15 x 1¼” track)

S2 – 2006 Polaris RMK 700 (144 x 15 x 2” track)

Individual Vehicle Observations

A1: 2005 Polaris Sportsman 700 ATV

Hill pass-by – four pass-bys were run at a speed of approximately 50 mph/80 kph. Tire impressions from downhill passes were 3 to 4 cm (1.2 to 1.6 in) deep and 25 to 26 cm (9.8 to 10.2 in) wide. Tire impressions left by uphill passes were 4 to 6 cm (1.6 to 2.4 in) deep and 22 to 25 cm (8.7 to 9.8 in) wide. Tire impressions at the bottom of the valley between the two hills were generally 2 cm (0.8 in) deep.



Photo 119: A fast pass-by



Photo 120: Tire impressions from a fast pass-by

A2: 2006 Polaris Predator 500 ATV

Hill pass-by – four pass-bys were run at a speed of approximately 45 to 50 mph/72 to 80 kph. Tire impressions from downhill passes were 1 to 2 cm (0.4 to 0.8 in) deep and 26 to 28 cm (10.2 to 11 in) wide. Tire impressions left by uphill passes were 2 to 3 cm (0.8 to 1.2 in) deep and 26 to 28 cm (10.2 to 11 in) wide. Tire impressions at the bottom of the valley between the two hills were generally 1 to 1.5 cm (0.4 to 0.6 in) deep.



Photo 121: A fast downhill pass-by



Photo 122: Tire impressions from a fast uphill pass-by

S1: 2006 Polaris Switchback 900 Snowmobile

Hill pass-by – four pass-bys were run at a speed of approximately 50 mph/80 kph. Track marks on both uphill and downhill pass-bys generally consisted of surface chew 1.5 to 3 cm (0.6 to 1.2 in) deep and 40 to 41 cm (15.7 to 16.1 in) wide. The same surface chew was also generally present at the bottom of the valley between the two hills.



Photo 123: A fast pass-by



Photo 124: Impressions from uphill fast pass-by

S2: 2006 Polaris RMK 700 Snowmobile
Hill pass-by – four pass-bys were run at a speed of approximately 50 mph/80 kph. Track impressions on both uphill and downhill pass-bys generally consisted of surface chew 2 to 5 cm (0.8 to 2 in) deep and 40 cm (15.7 in) wide. The same surface chew was also generally present at the bottom of the valley between the two hills. One additional observation was that footprints on the trail surface were generally 3 cm (1.2 in) deep.



Photo 125: Footprint on the trail surface



Photo 126: A fast pass-by



Photo 127: Impressions from a fast pass-by

Summary of Observations from the WI 2 Field Test

- ATV PASS-BYS: The relatively fast pass-bys on the hard trail surface left minimal tire impressions that were 2 to 6 cm (0.8 to 2.4 in) in depth. There was slightly more tire spin when traveling uphill, but no trenching or rutting of the trail surface.

- **SNOWMOBILE PASS-BYS:** The relatively fast pass-bys on the hard trail surface left minimal track impressions that were 1.5 to 5 cm (0.6 to 2 in) in depth. There was no noticeable track spin when traveling uphill and no trenching or rutting of the trail surface.
- **FOOTPRINTS:** Footprints on the trail surface were generally 3 cm (1.2 in) deep.

**Field Testing Journal: February 8, 2006
Iron River, Wisconsin (WI 3)**

Field Study Code/Number: WI 3

Location: State Corridor Trail 31 approx. 4 miles northeast of Iron River, Wisconsin

Elevation: 1345 feet

Temperature Range: 24.0 F/-4.4 C to 25.9 F/-3.4 C

Time of Day: 2:45 PM to 3:15 PM

Weather: clear, calm

Trail Aspect: flat through the woods; 140 degree curve that was 150 feet/45.7 meters in length

Trail Conditions: moderately packed snow surface with ice layer beneath; surface wear from traffic but was in good condition even though there had been lots of snowmobile traffic on the trail

Compacted Snow Depth: 4 to 17 cm (1.6 to 6.7 in) to ice layer – trail surface was compacted but the snow was nearly worn out so it did not bond well

Uncompacted snow depth adjacent to the trail: 20 to 40 cm (8 to 16 in)

Area Grooming Equipment: New Holland tractor with Lacrosse drag



Photo 128: Site of WI 3 field test

Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / ½” lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / ½” lugs, 4 psi)

S1 – 2006 Polaris Switchback 900 (144 x 15 x 1¼” track)

S2 – 2006 Polaris RMK 700 (144 x 15 x 2” track)

Individual Vehicle Observations

A1: 2005 Polaris Sportsman 700 ATV

140 degree curve pass-by – the four pass-bys were all relatively slow (25 to 30 mph/40 to 48 kph) since icy conditions near the trail surface led to the vehicles sliding easily when negotiating the curve. Visible tire tracks were 3 to 5 cm (1.2 to 2 in) deep and 16 to 19 cm (6.3 to 7.5 in) wide, although one pass resulted in tire tracks that were 27 cm (10.6 in) wide.



Photo 129: A curve pass-by



Photo 130: Impressions from a curve pass-by

A2: 2006 Polaris Predator 500 ATV

140 degree curve pass-by – the four pass-bys were all relatively slow (25 to 30 mph/40 to 48 kph) since icy conditions near the trail surface led to the vehicles sliding easily when negotiating the curve. Visible tire tracks were 3 to 8 cm (1.2 to 3.1 in) deep and 26 to 30 cm (10.2 to 11.8 in) wide. The last two passes were into the ice layer at the top of the curve and resulted in a 6 to 8 cm (2.4 to 3.1 in) high berm starting to form on the outside edge.



Photo 131: A curve pass-by



Photo 132: Berm created by curve pass-by

S1: 2006 Polaris Switchback 900 Snowmobile

140 degree curve pass-by – the four pass-bys were all relatively slow (25 to 30 mph/40 to 48 kph) since icy conditions near the trail surface led to the vehicle sliding easily when negotiating the curve. Visible track marks were 2 to 3 cm (0.8 to 1.2 in) deep and 40 cm (15.7 in) wide. All passes were into the ice layer at the top of the curve and resulted in a 5 cm (2 in) high berm starting to form on the outside edge.



Photo 133: A curve pass-by



Photo 134: Icy surface uncovered by curve pass-bys

S2: 2006 Polaris RMK 700 Snowmobile

140 degree curve pass-by – the four pass-bys were all relatively slow (25 to 30 mph/40 to 48 kph) since icy conditions near the trail surface led to the vehicle sliding easily when negotiating the curve. Visible track marks were 2 to 3 cm (0.8 to 1.2 in) deep and 47 cm (18.5 in) wide.



Photo 135: A curve pass-by



Photo 136: Impressions from a curve pass-by

Summary of Observations from the WI 3 Field Test

- **ATV OPERATION:** Passes by the ATVs generated tire tracks 3 to 8 cm (1.2 to 3.1 in) deep that were 16 to 30 cm (6.3 to 11.8 in) wide. A slight (8 cm/3.1 in) berm also began to form on the outside edge of the corner, but the height was limited by the ice layer just below the surface.
- **SNOWMOBILE OPERATION:** Passes by the snowmobiles generated track marks 2 to 3 cm (0.8 to 1.2 in) deep and 40 to 47 cm (15.7 to 18.5 in) wide. A slight (5 cm/2 in) berm also began to form on the outside edge of the corner, but the height was limited by the ice layer just below the surface.
- The curve was generally quite icy just below the surface which prevented much speed in the corner, as well as any significant impacts from any of the four vehicles sliding around/through the corner.

**Field Testing Journal: February 10, 2006
Soo Line South Trail; Moose Lake, Minnesota (MN 1)**

Field Study Code/Number: MN 1
Location: Soo Line South Trail, starting from the Moose Lake Depot
Elevation: 1081 feet
Temperature Range: 23.6 F/-4.7 C (start) to 27.0 F/-2.8 C (end)
Time of Day: 1:30 PM to 3:35 PM
Weather: clear, sunny, calm
Trail Aspect: railroad grade trail; flat
Trail Conditions: the first two miles of the trail heading east from the depot had been freshly groomed that morning; the balance of the trail had 6 to 10 cm (2.4 to 3.9 in) of new snow on it that fell the previous night (there was more new snow on the trail the farther you went from town); the trail base below the new snowfall was smooth and in good condition



Photo 137: Site of MN 1 Field Observations

Control Vehicles

- A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / ½” lugs, 4 psi)
- A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / ½” lugs, 4 psi)

Individual Vehicle Observations

A1 – 2005 Polaris Sportsman 700 ATV

The vehicle was ridden from the depot parking area east on the trail for a distance of nine miles and then back to the depot, for a total distance of 18 miles, with the following observations:

Operation on Freshly Groomed Portion of the Trail –

Tire impressions on the freshly groomed trail surface were 2 cm (0.8 in) deep and 26 cm (10.2 in) wide. Comparatively, track marks from other snowmobile traffic on the trail were 1 cm (0.4 in) deep and 40 cm (15.7 in) wide and were accompanied by ski skag marks that were 2 cm (0.8 in) deep and 4 cm (1.6 in) wide. Footprints from snow boots left a 1 cm (0.4 in) deep impression on the trail.



Photo 138: Tire, sled, and foot impressions on the groomed trail

Operation on Trail with New/Ungroomed Snow –

Tire impressions on the trail where there was 6 to 10 cm (2.4 to 3.9 in) of new snow that had not yet been groomed were 4 cm (1.6 in) deep and 28 cm (11 in) wide. Deliberate in-trail weaving also left the same 4 cm (1.6 in) deep and 28 cm (11 in) wide tire tracks. The vehicle handled much better than the Predator and was able to travel at a speed of 40 mph/64 kph while being only slightly “squirrely.” The vehicle was operated in 4WD the nine miles out from the parking area, and then in 2WD on the return trip. It was less squirrely in 4WD and tracked better than when it was operated in 2WD. One road crossing had 38 cm (15 in) high berms from the snowplow – there was spinning while crossing them in 2WD while they were not an issue when crossing them while in 4WD.



Photo 139: Tire impression on the new snowfall



Photo 140: Tire impressions in new snow



Photo 141: Impressions from in-trail weaving

A2 – 2006 Polaris Predator 500 ATV

The vehicle was ridden from the depot parking area east on the trail for a distance of six miles and then back to the depot, for a total distance of 12 miles, with the following observations:

Operation on Freshly Groomed Portion of the Trail – Tire impressions on the freshly groomed trail surface were 1 cm (0.4 in) deep and 26 cm (10.2 in) wide. Comparatively, snowmobile track and ski skag impressions from other traffic on the trail were 1 to 2 cm (0.4 to 0.8 in) deep and footprints from snow boots left a 1 cm (0.4 in) deep impression on the trail.



Photo 142: Tire imprints on groomed trail surface



Photo 143: Tire and footprint impressions

Operation on Trail with New/Ungroomed Snow – Tire impressions on the trail where there was 6 cm (2.4 in) of new snow that had not yet been groomed were 4 cm (1.6 in) deep and 26 cm (10.2 in) wide. When shifting the vehicle between gears while accelerating during takeoff, piles of snow that were 12 cm (4.7 in) high, 32 cm (12.6 in) wide, and 36 cm (14.2 in) long were left on the trail by the tires. Deliberate in-trail turns (cookies/doughnuts in the middle of the trail) dug 6 cm (2.4 in) deep and 24 to 26 cm (9.5 to 11 in) wide ruts in the trail. These ruts were down to an ice layer; otherwise, the ruts would likely have been even deeper. This also created 12 to 14 cm (4.7 to 5.5 in) high berms at the outside edges of the turn.



Photo 144: Tire impressions on fresh snow

Again, these likely would have been higher if there had not been the ice layer in the trail. The vehicle handled better when it could follow a track made in the snow by previous snowmobile traffic. Overall, the vehicle was very “squirrely” and it felt like its front tires were skating around all of the time, making it hard to control.



Photo 145: Snow piles from shifting gears



Photo 146: Impressions from an in-trail turn

Summary of Observations from the MN 1 Field Test

- This field test was a good opportunity to observe ATV operation on a real trail open to concurrent use by both ATVs and snowmobiles. The trail also had 6 to 10 cm (2.4 to 3.9 in) of new snow on it, which also offered a perspective that had not yet been observed. The two control ATVs were operated a combined total of 30 miles (48 kilometers) on the trail.
- The Sportsman ATV handled the trail conditions quite well and was enjoyable to ride at all speeds. Tire impressions were generally 4 cm (1.6 in) deep and 28 cm (11 in) wide in the new snow on the trail, irrespective as to whether it was normal operation down the trail or deliberate in-trail weaving with the vehicle.
- The Predator ATV was generally very squirrely to operate and generally felt unsafe on this trail surface at all but a very low speed. Tire impressions were also generally 4 cm (1.6 in) deep, but 26 cm (10.2 in) wide, when going down the trail with the new snow. Deliberate in-trail turns dug 6 cm (2.4 in) deep ruts down to the ice layer of the trail's base. The vehicle also left small piles of snow generally 12 cm (4.7 in) high, 32 cm (12.6 in) wide, and 36 cm (14.2 in) long when shifting between gears.

Field Testing Journal: February 11, 2006

Gandy Dancer Trail and St. Croix State Forest, Minnesota (MN 2)

Field Study Code/Number: MN 2

Location: Gandy Dancer Trail and St. Croix State Forest, starting from the Danbury, Wisconsin trailhead which is located just across the state line from the trail

Elevation: 930 feet

Temperature Range: 17.0 F/-8.3 C (start) to 30.8 F/-0.7 C (end)

Time of Day: 10:30 AM to 1:30 PM

Weather: clear, sunny, calm

Trail Aspect: the main trail was flat and located on an old railroad grade; the side trails on the state forest were hilly and winding through the forest on narrow logging trails

Trail Conditions: the first one mile (1.6 km) north from the parking lot to the St. Croix River Bridge (the Minnesota state line) was ungroomed and heavily moguled. The railroad grade trail north from the bridge had been groomed, but not since there had been new snowfall. There was 8 to 10 cm (3.1 to 3.9 in) of new snow

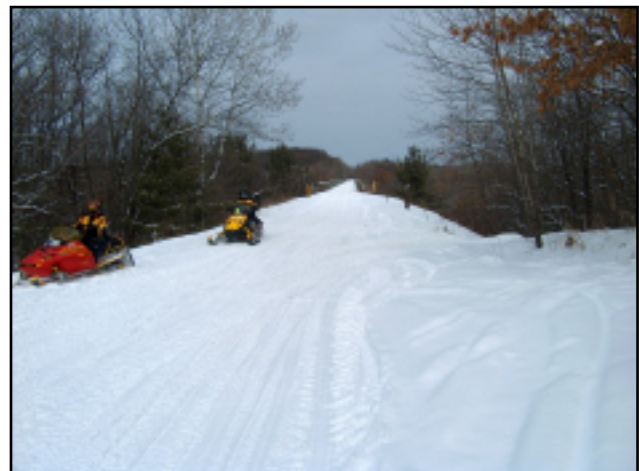
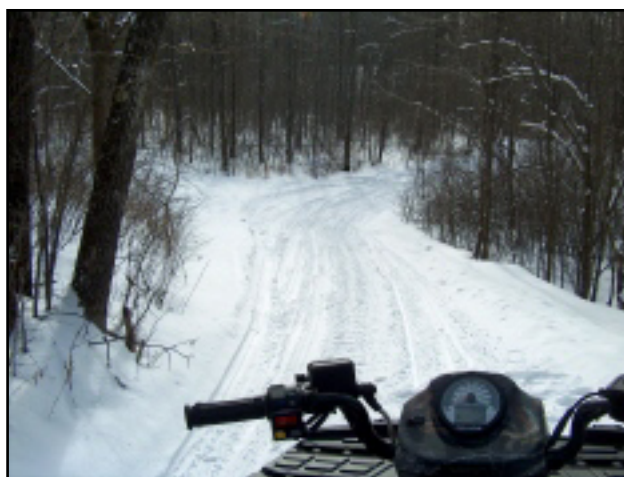


Photo 147: Railroad grade trail at Site MN 2

that had been heavily trafficked by snowmobiles. The side trails on the state forest had 10 to 20 cm (3.9 to 7.9 in) of new snowfall that had not been trafficked or groomed, which provided a bit of a fresh powder characteristic.

Photo 148: Site MN 2 side trails



Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / ½” lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / ½” lugs, 4 psi)

Individual Vehicle Observations

A1 – 2005 Polaris Sportsman 700 ATV

The vehicle was ridden from the parking area north on the railroad grade trail to Markville, a distance of about 6 miles (9.7 km), and then back south to the state forest side trails where various loops totaling 19 miles (30.6 km) were ridden before returning to the parking area in Danbury via the railroad grade trail. A total distance of 31 miles (49.9 km) were ridden, 12 miles (19.3 km) on the railroad grade and 19 miles (30.6 km) on the state forest, with the following observations:



Photo 149: Vehicle on the railroad grade trail

Operation on the Railroad Grade Trail – There was 8 to 10 cm (3.1 to 3.9 in) of new snow on the trail that had been heavily trafficked and beaten down by snowmobiles. Tire impressions on the trail surface were 2 cm (0.8 in) deep and 26 cm (10.2 in) wide. Comparatively, track marks from other snowmobile traffic on the trail were generally 1 cm (0.4 in) deep and 38 cm (15 in) wide and were accompanied by ski skag marks that were 1 cm (0.4 in) deep and 4 cm (1.6 in) wide. The vehicle reached a top speed of 45 mph/ 72 kph and was relatively

stable, although there was a tendency to want to hug the middle of the trail, particularly where the grade was very high and elevated. The vehicle was operated in both 2-wheel drive (2WD) and 4-wheel drive (4WD) with 4WD providing a more stable feeling of being in control of the vehicle. In 2WD, there was a greater tendency for the rear end of the vehicle to spin and wander. In 4WD, you could feel the difference of the front wheels helping to pull the vehicle. The vehicle was extremely cold to operate (no windshield, hand warmers or cowling to offer protection),

particularly when going down the trail at 45 mph/72 kph. Snowmobile traffic was relatively heavy (approximately 90 sleds over the three hour period) on the trail (it was a Saturday morning/early afternoon), as compared to seeing only one other ATV on the trail over the same time period.



Photo 150: ATV and snowmobile impressions on the trail



Photo 151: Snowmobile and footprint impressions



Photo 152: Tire impression on packed trail

Operation on the State Forest Side Trails – There was 10 to 20 cm (3.9 to 7.9 in) of new snowfall on the side trail loops that had not been heavily trafficked or groomed, with over half of the trails having had no prior traffic on the new snowfall. Tire impressions where there was 20 cm (7.9 in) of new snow were 17 cm (6.7 in) deep and 29 cm (11.4 in) wide. In another location where the new snow was 14 cm (5.5 in) deep, the tire impressions in the snow were 12 cm (4.7 in) deep. And where the new snowfall was 18 cm (7.1 in) deep, the tire impressions were 15 cm (5.9 in) deep. Generally, in all locations that were sampled, the tire impressions in the new snow were 2 to 3 cm (0.8 to 1.2 in) less than what the total depth of the new snowfall was. Said another way, the tires consistently compressed the new snow to a depth of 2 to 3 cm (0.8 to 1.2 in). On a 25 mph/40 kph pass-by through a particularly winding and hilly section of the trail, 8 to 10 cm (3.1 to 3.9 in) high and 20 cm (7.9 in) wide berms were created at the outside edges of the trail. However, these berms were re-leveled by only two snowmobiles passing over the same trail soon after they had been created. The vehicle was operated in 2-wheel drive (2WD) mode for only a short distance since it generally struggled and was hard to control in the deeper snow. The 4-wheel drive (4WD) mode provided much better control, particularly when negotiating the curves and hills. Snowmobile traffic was relatively light (approximately 10 sleds over the three hour period) on the trail. Generally, in 4WD mode, the vehicle provided a very enjoyable ride and negotiated the trail features well at a speed of 20 to 25 mph/32 to 40 kph. Four other ATVs (a group of three ATVs and a single rider on a 3-wheeler) were seen on these trail loops over the same time period.



Photo 153: Fresh snowfall on the side trails



Photo 154: The vehicle in fresh snow



Photo 155: Tracks in the fresh snow



Photo 156: Tire impression in fresh snow



Photo 157: Downhill on a side trail



Photo 158: Around a curve on a side trail

A2 – 2006 Polaris Predator 500 ATV

The vehicle was ridden from the parking area north on the railroad grade trail to turn-off to the state forest side trails, a distance of about 2.5 miles (4 km). It was then ridden a short distance on the state forest side trails, about 3.5 miles (5.6 km), at which point the vehicle was turned around and ridden back to the trailhead in Danbury. The ATV was ridden a total distance of about 12 miles (19.3 km), 5 miles (8 km) on the railroad grade and about 7 miles (11.3 km) on the state forest, with the following observations:

Operation on the Railroad Grade Trail – There was 8 to 10 cm (3.1 to 3.9 in) of new snow on the trail that had been heavily trafficked and beaten down by snowmobiles. Tire impressions on the trail surface were 1 cm (0.4 in) deep and 27 cm (10.6 in) wide. Comparatively, track marks from snowmobile traffic on the trail were generally 1 cm (0.4 in) deep and 38 cm (15 in) wide and accompanied by ski skag marks that were 1 cm (0.4 in) deep and 4 cm (1.6 in) wide. The vehicle had a difficult time negotiating the rough moguls near the trailhead

since the short wheel base of the vehicle made it very hard to control the vehicle as it went up and down in the deep holes. Overall, the vehicle was very hard to control, very squirrely, and didn't have a very safe feel going down the trail. The vehicle was extremely cold to operate (no windshield, hand warmers or cowling to offer protection).

Snowmobile traffic was relatively heavy on the trail and, when meeting snowmobile traffic, it required slowing the vehicle way down – nearly to a stop – to keep control of the vehicle at the edge of the trail where there was more new snow that had not been compressed by the snowmobile traffic on the trail.



Photo 159: Tire impression on the railroad grade trail

Operation on the State Forest Side Trails – There was 10 to 20 cm (3.9 to 7.9 in) of new snowfall on the side trail loops that had not been heavily trafficked or groomed, with over half of the trails having had no prior traffic on the new snowfall. Tire impressions where there was 10 cm (3.9 in) of new snow were 9 cm (3.5 in) deep and 27 cm (10.6 in) wide. In another location where the new snow was 17 cm (6.7 in) deep, the tire impressions in the snow were 15 cm (5.9 in) deep and 28 cm (11 in) wide. Generally, in all locations that were sampled, the tire impressions in the new snow were 1 to 2 cm (0.4 to 0.8 in) less than what the total depth of the new snowfall was. Said another way, the tires consistently compressed the new snow to a depth of 1 to 2 cm (0.4 to 0.8 in). The front tires of this 2-wheel drive (2WD) vehicle tended to “push” in the deeper snow that was moderately moist (the snow easily made a loose snowball) and the vehicle was particularly hard to control. Also, in the 17 cm (6.7 in) deep new snowfall, the front A-arm/steering and suspension on the vehicle had only 1 cm (0.4 in) of clearance between it and the top of the snow since the front tires penetrated the new snow to a depth of 16 cm (6.3 in), which could make the operation of this vehicle in much deeper snow very difficult, if not impossible. While the Sportsman ATV (A1) easily negotiated these same side trails at 20 to 25 mph/32 to 40 kph, this vehicle struggled to negotiate them at 10 to 15 mph/16 to 24 kph. The vehicle was extremely squirrely to operate and it felt very unsafe to operate under the same conditions that, just a short time earlier, the Sportsman had easily handled in a much safer manner.



Photo 160: Tracks on a side trail



Photo 161: Snow is almost as deep as vehicle's suspension



Photo 162: Tire impression in new snow

Summary of Observations from the MN 2 Field Test

- This field test was another good opportunity to observe ATV operation on a variety of real trails open to concurrent use by both ATVs and snowmobiles. The railroad grade trail had 8 to 10 cm (3.1 to 3.9 in) of new snow that had been heavily trafficked by snowmobiles, while the side trails on the state forest had 10 to 20 cm (3.9 to 7.9 in) of new snowfall that had not been trafficked or groomed and provided somewhat of a fresh powder characteristic. The two control ATVs were operated a combined total of 45 miles (72 kilometers) on these trails.
- The Sportsman ATV handled the trail conditions quite well and was enjoyable to ride at all speeds. The winding and hilly side trails were a particularly enjoyable experience on this vehicle. Tire impressions on the railroad grade trail were generally 2 cm (0.8 in) deep and 26 cm (10.2 in) wide in the new snow on the trail that had been heavily trafficked by snowmobiles. On the side trails, tire impressions ranged from being 12 cm (4.7 in) to 17 cm (6.7 in) deep and generally compressed the new snow to a depth of 2 to 3 cm (0.8 to 1.2 in).
- The Predator ATV was generally very squirrely to operate and generally felt unsafe on these trails, particularly in the new snow on the side trails. Tire impressions on the railroad grade trail were generally 1 cm (0.4 in) deep and 27 cm (10.6 in) wide. On the side trails, tire impressions ranged from being 9 cm (3.5 in) deep to 15 cm (5.9 in) deep and generally compressed the new snow to a depth of 1 to 2 cm (0.4 to 0.8 in).

**Field Testing Journal: February 21, 2006
Paris Canyon, Idaho (ID 1)**

Field Study Code/Number: ID 1

Location: Paris Canyon Trail approximately 2 miles west of the Paris Canyon parking area; near Paris, Idaho

Elevation: 7535 feet

Temperature Range: 25.0 F/-3.9 C (start) to 21.4 F/-5.9 C (end)

Time of Day: 10:10 AM to 12:05 PM

Weather: cloudy, flat light, 6 mph/9.6 kph wind

Trail Aspect: on a flat, open roadway with a 4% grade

Trail Conditions: smooth and in good condition, slightly wind blown; was groomed 3 hours prior to testing; good compaction with hard trail base but 2 cm (0.8 in) of loose snow on the surface due to recent grooming (trail base had not fully setup)

Compacted Snow Depth: 60 cm (23.6 in) to ground, packed hard but with 2 cm (0.8 in) loose snow on top due to fresh grooming

Uncompacted snow depth adjacent to the trail: 64 to 76 cm (25 to 30 inches)

Area Grooming Equipment: Pisten Bully EDGE with a 12-foot tiller



Photo 163: ID 1 field test site

Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / ½” lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / ½” lugs, 4 psi)

S1 – 2006 Polaris Switchback 900 (144 x 15x 1¼” track)

S2 – 2006 Polaris RMK 700 (144 x 15 x 2” track)

Other Vehicles

A3 – 2003 Suzuki Vinson 500 (4x4; auto transmission; 25 x 10-12 rear tires / 3/8” lugs, 6 psi)

A4 – 2001 Polaris Scrambler 500 (4x4; auto transmission; 22 x 11-10 rear tires / 5/8” lugs, 9 psi)

Individual Vehicle Observations

Note: Due to flat light conditions, it was difficult to get photos with good contrast to document this field test.

A1: 2005 Polaris Sportsman 700 ATV

Slow/normal track – all starts, stops, and 15 mph/24 kph pass-bys resulted in tire “surface chew” that was 2 to 3 cm (0.8 to 1.2 in) deep and 23 to 24 cm (8.7 to 9.5 in) wide. Tire tracks were visible and consistent the entire length all zones.

Fast/aggressive track – starts resulted in tire tracks that were 3 to 6 cm (1.2 to 2.4 in) deep and 22 to 28 cm (8.7 to 11 in) wide. The 35 mph/56 kph pass-bys resulted in visible tire tracks 3 cm (1.2 in) deep and 24 cm (9.5 in) wide and left no visible trenching or rutting. Stops resulted in tire impressions that were 3 to 5 cm (1.2 to 2 in) deep and 20 to 28 cm (7.9 to 11 in) wide. Top vehicle speed varied from 26 to 29 mph/42 to 47 kph uphill and 33 to 35 mph/53 to 56 kph downhill,



Photo 164: Impressions from a fast pass-by

which caused the stopping distance to vary. The uphill stopping distance ranged from 9.4 to 9.6 meters (30.8 to 31.5 feet) while the downhill stopping distance ranged from 12.8 to 12.9 meters (42.1 to 42.3 feet). The overall average stopping distance was 11.2 meters (36.7 feet), although the downhill average stopping distance of 12.9 meters (42.2 feet) provides a better comparison in respect to other tests that were run at 35 mph/56 kph.



Photo 165: An aggressive start



Photo 166: Impressions from an aggressive stop

A2: 2006 Polaris Predator 500 ATV

Slow/normal track – the vehicle got off the compacted trail base on the first slow run and became stuck, which resulted in tire ruts that were 16 cm (6.3 in) deep and 32 cm (12.6 in) wide. All starts, stops, and 15 mph/24 kph pass-bys on the compacted trail surface resulted in tire “surface chew” that was 2 cm (0.8 in) deep and 28 cm (11 in) wide. Tire tracks were visible and consistent the entire length all zones.

Fast/aggressive track – starts resulted in tire tracks that were 5 to 12 cm (2 to 4.7 in) deep and 26 to 28 cm (10.2 to 11 in) wide. The 35 mph/56 kph pass-bys resulted in visible tire tracks 2 to 5 cm (0.8 to 2 in) deep and 28 cm (11 in) wide. Stops resulted in tire impressions that were 3 to 7 cm (1.2 to 2.8 in) deep and

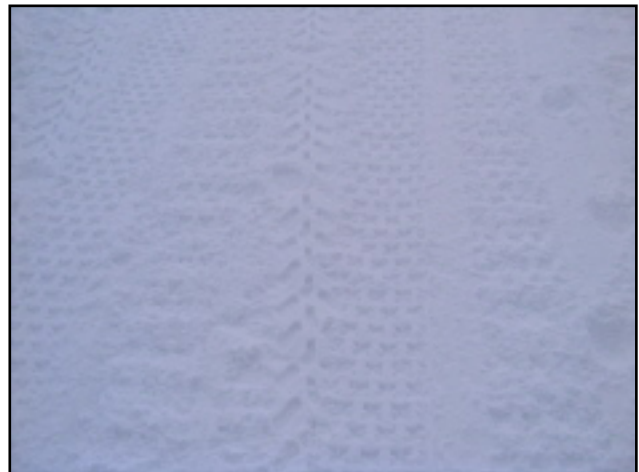


Photo 167: Surface chew from slow pass



Photo 168: Impressions from an aggressive start



Photo 169: Impressions from an aggressive stop

28 to 30 cm (11 to 11.8 in) wide. Stopping distance at 35 mph/56 kph varied widely depending upon whether the vehicle was stopping uphill or downhill on the 4% grade. The uphill stopping distance ranged from 11.3 to 13.0 meters (37.1 to 42.6 feet) while the downhill stopping distance ranged from 18.7 to 22.2 meters (61.5 to 72.9 feet). The overall average stopping distance was 16.3 meters (53.5 feet), although the downhill average stopping distance of 20.5 meters (67.2 feet) most likely provides a better comparison in respect to other tests that were run at 35 mph/56 kph.

Other – footprints on the trail surface were 5 cm (2 in) deep. Also, the vehicle got stuck on the first slow run even though the operator was on what looked like a “fresh groomed” trail surface. However, the fresh grooming marks were wider than what the compacted trail surface was since the most recent grooming pass had widened the trail. The result was that, even though the outside edges of the trail “looked to be part of” the groomed trail base, both outside edges were not compacted sufficient enough to support ATV traffic.



Photos 170 and 171: The vehicle got off the edge of the compacted base and got stuck

A3: 2003 Suzuki Vinson 500 ATV

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in tire tracks that were 3 to 5 cm (1.2 to 2 in) deep and 15 to 22 cm (5.9 to 8.7 in) wide. The pass-bys resulted in tire tracks 1.5 cm (0.6 in) deep with no visible trenching or rutting of the trail surface. Stops resulted in tire impressions that were 2 to 4 cm (0.8 to 1.6 in) deep and 18 to 20 cm (7.1 to 7.9 in) wide. The top pass-by speed was 31 mph/50 kph when operating uphill and 35 mph/56 kph when operating downhill. This, along with the slight grade, caused the stopping distance to vary widely depending upon whether the vehicle was stopping uphill or downhill on the 4% grade. The uphill stopping distance ranged from 11.6 to 13.4 meters (38.0 to 43.8 feet) while the downhill stopping distance ranged from 23.6 to 25.1 meters (77.4 to 82.3 feet). The overall average stopping distance was 18.4 meters (60.4 feet), although the downhill average stopping distance of 24.4 meters (79.9 feet) most likely provides a better comparison in respect to other tests that were run at 35 mph/56 kph.



Photo 172: An aggressive start



Photo 173: An aggressive stop

A4: 2001 Polaris Scrambler 500 ATV

Slow/normal track – this vehicle was run only on the fast/aggressive track

Fast/aggressive track – starts resulted in tire tracks that were 3 to 5 cm (1.2 to 2 in) deep and 21 to 24 cm (8.3 to 9.5 in) wide. The pass-bys resulted in tire tracks 3 cm (1.2 in) deep with no visible trenching or rutting of the trail surface. Stops resulted in tire impressions that were 2.5 to 6 cm (1 to 2.4 in) deep and 23 to 27 cm (9.1 to 10.6 in) wide. Stopping distance at 35 mph/56 kph on the slight 4% grade varied widely depending upon whether the vehicle was stopping uphill or downhill. The uphill stopping distance ranged from 9.5 to 12.4 meters (31.1 to 40.8 feet) while the downhill stopping distance ranged from 17.4 to 18.7 meters (57.0 to 61.5 feet). The overall average stopping distance was 14.5 meters (47.6 feet), although the downhill average stopping distance of 18.1 meters (59.3 feet) most likely provides a better comparison in respect to other tests that were run at 35 mph/56 kph.



Photo 174: An aggressive start



Photo 175: An aggressive stop

S1: 2006 Polaris Switchback 900 Snowmobile

Slow/normal track – all starts, stops, and 15 mph/24 kph pass-bys resulted in 2 cm (0.8 in) deep and 40 cm (15.7 in) wide “surface chew” from the track. 2.5 cm (1 in) wide and 4 cm (1.6 in) deep grooves from the ski skags were also visible. The skag marks and surface chew were visible and consistent the entire length of the start, pass-by, and stop zones.

Fast/aggressive track – starts resulted in track marks that were 4 to 5 cm (1.6 to 2 in) deep and 38 to 39 cm (15 to 15.4 in) wide. The 35 mph/56 kph pass-bys resulted in “surface chew” from the track that was 3 cm (1.2 in)

deep and 38 to 39 cm (15 to 15.4 in) wide. There was no visible trenching or rutting of the trail. The 2.5 cm (1 in) wide and 4 cm (1.6 in) deep ski skag marks were also visible throughout the fast track area. Stops resulted in track impressions that were generally 3 to 5 cm (1.2 to 2 in) deep and 47 cm (18.5 in) wide. Stopping distance at 35 mph/56 kph on the slight 4% grade varied slightly depending upon whether the vehicle was stopping uphill or downhill. The uphill stopping distance ranged from 19.6 to 21.9 meters (64.3 to 71.8 feet) while the downhill stopping distance ranged from 24.8 to 26.5 meters (81.3 to 87.0 feet). The overall average stopping distance was 23.2 meters (76.1 feet), although the downhill average stopping distance of 25.7 meters (84.2 feet) most likely provides a better comparison in respect to other stopping tests run at 35 mph/56 kph.



Photo 176: An aggressive start



Photo 177: An aggressive stop

S2: 2006 Polaris RMK 700 Snowmobile

Slow/normal track – all starts, stops, and 15 mph/24 kph pass-bys resulted in 2 to 3 cm (0.8 to 1.2 in) deep and 40 cm (15.7 in) wide “surface chew” from the track. 3 cm (1.2 in) wide and 4 cm (1.6 in) deep grooves from the ski skags were also visible. The skag marks and surface chew were visible and consistent the entire length of the start, pass-by, and stop zones.

Fast/aggressive track – starts resulted in track marks that were 4 to 7 cm (1.6 to 2.8 in) deep and 39 to 42 cm (15.4 to 16.5 in) wide. The 7 cm (2.8 in) deep start also left a 12 cm (4.7 in) high pile of snow behind the track on take off. The 35 mph/56 kph pass-bys resulted in “surface chew” from the track that was 3 to 4 cm (1.2 to 1.6 in) deep and 42 to 45 cm (16.5 to 17.7 in) wide.



Photo 178: Surface chew from a slow pass-by

There was no visible trenching or rutting of the trail. The 3 cm (1.2 in) wide and 4 cm (1.6 in) deep ski skag marks were also visible throughout the fast track area. Stops resulted in track impressions that were generally 4 to 5 cm (1.6 to 2 in) deep and 39 to 42 cm (15.4 to 16.5 in) wide. Stopping distance at 35 mph/56 kph on the slight 4% grade varied depending upon whether the vehicle was stopping uphill or downhill. The uphill stopping distance ranged from 17.9 to 19.3 meters (58.8 to 63.3 feet) while the downhill stopping distance ranged from 26.4 to 27.3 meters (86.5 to 89.5 feet). The overall average stopping distance was 22.7 meters (74.5 feet), although the downhill average stopping distance of 26.8 meters (88.0 feet) most likely provides a better comparison in respect to other stopping tests run at 35 mph/56 kph.



Photo 179: An aggressive start



Photo 180: Impressions from an aggressive stop

Summary of Observations from the ID 1 Field Test

- **SLOW/NORMAL OPERATION:** None of the vehicles created noticeable adverse impacts when operated in the slow/normal mode whether in the start, 15 mph/24 kph pass-by, or stop zones. There was only normal surface chew that was 2 to 3 cm (0.8 to 1.2 in) deep.
- **FAST/AGGRESSIVE PASS-BY:** None of the vehicles created noticeable adverse impacts when operated in the 35 mph/56 kph pass-by mode. There was only surface chew that was 1.5 to 5 cm (0.6 to 2 in) deep.
- **AGGRESSIVE STARTS:** ATVs created deeper impressions in the trail than what snowmobiles did. Aggressive starts resulted in ATV tire impressions 3 to 12 cm (1.2 to 4.7 in.) deep and 15 to 28 cm (5.9 to 11 in.) wide. Snowmobile track impressions were 4 to 7 cm (1.6 to 2.8 in.) deep and 38 to 42 cm (15 to 16.5 in.) wide. The deepest ATV tire tracks from the Predator were 5 cm (2 in) deeper than the deepest snowmobile track impressions from the RMK.
- **AGGRESSIVE STOPS:** ATVs created slightly deeper impressions in the trail than what snowmobiles did. Aggressive stops resulted in ATV tire impressions 2 to 7 cm (0.8 to 2.8 in.) deep and 18 to 30 cm (7.1 to 11.8 in.) wide. Snowmobile track impressions were 3 to 5 cm (1.2 to 2 in.) deep and 39 to 47 cm (15.4 to 18.5 in.) wide. The deepest ATV tire tracks from the Predator were 2 cm (0.8 in) deeper than the deepest snowmobile track impressions from both snowmobiles.
- **AVERAGE STOPPING DISTANCE – ALL VEHICLES:** When comparing all vehicles tested, the ATVs generally stopped quicker than the snowmobiles. The Sportsman stopped the quickest of the four ATVs and the RMK stopped the quicker of the two snowmobiles. The Suzuki Vinson required the greatest distance to stop of the four ATVs, while the Switchback required the greatest distance to stop of the two snowmobiles. The average ATV stopping distances at 35 mph/56 kph ranged from 11.2 to 18.4 meters (36.7 to 60.4 feet). The average snowmobile stopping distance ranged from 22.7 to 23.2 meters (74.5 to 76.1 feet). The minimum average ATV stopping distance (the Sportsman) was 11.5 meters/37.7 feet (50.7%) less than the shortest average snowmobile (the RMK) stopping distance, while the maximum average snowmobile stopping distance (the Switchback) was 4.8 meters / 15.7 feet (26.1%) greater than the longest average ATV (the Vinson) stopping distance.
- **AVERAGE STOPPING DISTANCE – CONTROL VEHICLES:** When comparing just the four control vehicles, the ATVs generally stopped quicker than the snowmobiles. The Sportsman stopped quicker of the two control ATVs, while the Switchback required the greatest distance to stop of the two control snowmobiles. The average ATV stopping distances at 35 mph/56 kph ranged from 11.2 to 16.3 meters (36.7 to 53.5 feet), while the average snowmobile stopping distance ranged from 22.7 to 23.2 meters (74.5 to 76.1 feet). The minimum average ATV stopping distance (the Sportsman) was 11.5 meters/37.7 feet (50.7 %) less than the shortest average snowmobile (the RMK) stopping distance, while the maximum average snowmobile stopping distance (the Switchback) was 6.9 meters/22.6 feet (42.3%) greater than the longest average ATV (the Predator) stopping distance.
- **DOWNHILL AVERAGE STOPPING DISTANCE – ALL VEHICLES:** The testing area had a 4% grade which caused the stopping distance at 35 mph/56 kph to vary slightly depending upon whether the vehicle

was stopping uphill or downhill. Therefore, the downhill average stopping distance most likely provides a better comparison in respect to other 35 mph/56 kph stopping tests run at other flatter test sites. When comparing the downhill average stopping distance of all vehicles tested, the ATVs generally stopped quicker than the snowmobiles. The Sportsman stopped the quickest of the four ATVs and the Switchback stopped the quicker of the two snowmobiles. The Suzuki Vinson required the greatest distance to stop of the four ATVs, while the RMK required the greatest distance to stop of the two snowmobiles. The downhill average ATV stopping distances at 35 mph/56 kph ranged from 12.9 to 24.4 meters (42.2 to 79.9 feet). The downhill average snowmobile stopping distance ranged from 25.7 to 26.8 meters (84.2 to 88.0 feet). The minimum downhill average ATV stopping distance (the Sportsman) was 12.8 meters/42.0 feet (49.8 %) less than the shortest downhill average snowmobile (the Switchback) stopping distance, while the maximum downhill average snowmobile stopping distance (the RMK) was just 2.4 meters / 7.9 feet (9.8%) greater than the longest downhill average ATV (the Vinson) stopping distance.

- **DOWNHILL AVERAGE STOPPING DISTANCE – CONTROL VEHICLES:** The testing area had a 4% grade which caused the stopping distance at 35 mph/56 kph to vary slightly depending upon whether the vehicle was stopping uphill or downhill. Therefore, the downhill average stopping distance most likely provides a better comparison in respect to other 35 mph/56 kph stopping tests run at other flatter test sites. When comparing the downhill average stopping distance of just the four control vehicles, the ATVs generally stopped quicker than the snowmobiles. The Sportsman stopped quicker of the two control ATVs, while the RMK required the greatest distance to stop of the two control snowmobiles. The downhill average ATV stopping distances at 35 mph/56 kph ranged from 12.9 to 20.5 meters (42.2 to 67.2 feet), while the downhill average snowmobile stopping distance ranged from 25.7 to 26.8 meters (84.2 to 88.0 feet). The minimum downhill average ATV stopping distance (the Sportsman) was 12.8 meters/42.0 feet (49.8 %) less than the shortest downhill average snowmobile (the Switchback) stopping distance, while the maximum average downhill snowmobile stopping distance (the RMK) was 6.3 meters/20.7 feet (30.7%) greater than the longest average downhill ATV (the Predator) stopping distance.
- The Predator ATV got stuck when its right wheels dropped off the compacted trail surface during the slow testing. Even though the operator was on what looked like a fresh groomed trail surface, the fresh grooming marks were actually wider than the compacted trail surface since the recent grooming had widened the trail. So even though the outside edges of the trail looked to be part of the groomed trail base, both outside edges of the trail were not compacted sufficient enough to support ATV traffic.
- Impressions from footprints on the test track were 5 cm (2 in) deep.

Field Testing Journal: February 21, 2006
Paris Canyon, Idaho (ID 2)

Field Study Code/Number: ID 2

Location: Paris Canyon Trail approximately 7 miles west of the Paris Canyon parking area at the junction of Forest Service Roads 421 and 408; near Paris, Idaho

Elevation: 7880 feet

Temperature Range: 19.0 F/-7.2 C

Time of Day: 12:15 PM to 1:05 PM

Weather: cloudy, 21 mph/33.8 kph wind with 35+ mph/56+ kph gusts

Trail Aspect: a sweeping curve at the bottom of a switchback with a rise of 30.5 meters / 100 feet over a distance of 0.4 kilometer / 0.25 mile

Trail Conditions: very wind blown and heavily drifted

Control Vehicles

A1 – 2005 Polaris Sportsman EFI 700 (4x4; auto transmission; 26 x 11R-12 rear tires / ½” lugs, 4 psi)

A2 – 2006 Polaris Predator 500 (2x4; manual transmission; 20 x 11-9 rear tires / ½” lugs, 4 psi)

S1 – 2006 Polaris Switchback 900 (144 x 15 x 1¼” track)

S2 – 2006 Polaris RMK 700 (144 x 15 x 2” track)

Other Vehicles

A3 – 2003 Suzuki Vinson 500 (4x4; auto transmission; 25 x 10-12 rear tires / 3/8” lugs, 6 psi)

A4 – 2001 Polaris Scrambler 500 (4x4; auto transmission; 22 x 11-10 rear tires / 5/8” lugs, 9 psi)

Observations

Site ID 2 was a climbing curve located approximately 5 miles beyond site ID 1. All test vehicles were driven to this site with the intent of measuring impacts on the climbing curve. The group encountered heavy winds and heavy drifting as it approached the new test site, with heavy pillow drifts across the trail for the last mile of the trip.

The Suzuki Vinson (A3) and the Polaris Scrambler (A4) were the first ATVs to reach the site and quickly became stuck as soon as they tried to go up the hill. The Vinson dug 12 cm (4.7 in) deep ruts before it could no longer go uphill in the drifted snow, while the Scrambler dug 24 cm (9.5 in) deep ruts before it could no longer go uphill and became stuck just a short distance up the curve. The other two control ATVs also struggled for the last mile of the trip while negotiating the pillow drifts and turned around at the bottom of the curve before reaching the location where the Vinson and Scrambler were stuck.

By comparison, the two control snowmobiles easily negotiated the drifts on the hill and curve and left track impressions on the drifted snow that were only 4 cm (1.6 in) deep.

Given the severe drifting conditions and the fact that the ATVs became stuck before making it very far up the curve, the group cancelled the remainder of the climbing curve test and returned to the trailhead.

APPENDIX B: SURVEY OF TRAIL MANAGERS

International Association of Snowmobile Administrators (IASA) EVALUATION OF ATV USE ON GROOMED SNOWMOBILE TRAILS SURVEY OF TRAIL MANAGERS

This survey is being conducted by Trails Work Consulting to gather information for a project sponsored by the International Association of Snowmobile Administrators, *Evaluation of ATV Use on Groomed Snowmobile Trails*. One part of this evaluation project includes collecting information from jurisdictions across the Snowbelt to identify information and issues related to **allowing concurrent ATV use on groomed snowmobile trails** during the winter season.

This survey is collecting information to help identify:

1. Jurisdictions that allow some level of concurrent snowmobile/ATV use on groomed snowmobile trails, including examples of their laws, rules, regulations, and management policies for this concurrent use;
2. Jurisdictions that do not allow any concurrent snowmobile/ATV use on groomed snowmobile trails, including their reasons why and examples of their laws, rules, regulations, and management policies prohibiting concurrent use;
3. Any statistics related to crashes, social conflicts or other incidents that are the result of concurrent snowmobile/ATV use on groomed snowmobile trails;
4. Testimonials or case studies of successful concurrent snowmobile/ATV use on groomed snowmobile trails; and
5. Information related to potential off-season impacts on snowmobile trails as the result of unauthorized ATV use. Results from this survey will be used to develop recommendations for 'best business practices' for managing ATV use on groomed snowmobile trails.

Please take a few minutes to complete this survey and return it to Trails Work Consulting by December 9, 2005. **Please respond regardless of whether your jurisdiction allows or prohibits concurrent snowmobile/ATV use** since your answers will help gauge the degree that this may be an accepted management practice across the Snowbelt. If you are not person best able to complete this survey for your jurisdiction, please forward it to the person who is. If you have questions about this survey, please contact Kim Raap at 605-371-9799 or by e-mailing Trailswork@aol.com. *Thank you for your assistance and prompt response!*

Agency/Organization/State/Province: _____
Name of Person Completing Survey: _____ Title: _____
Phone: _____ E-Mail Address: _____
Mailing Address: _____

Part I: Please check the situation below (No or Yes) that applies to your agency, organization, state, or provincial jurisdiction and provide the requested information as it applies to your area.

_____ **No**, our jurisdiction does not allow any level of concurrent ATV use on groomed snowmobile trails during the winter season.

- A. Please indicate how concurrent ATV use on groomed snowmobile trails is prohibited in your area: (please check all that are applicable)

_____ legislation _____ rule/regulation _____ policy _____ no formal action to prohibit

_____ other (explain): _____

- B. Please explain reason(s) why concurrent ATV use is not allowed on groomed snowmobile trails in your jurisdiction:

C. Total miles/kilometers of groomed snowmobile trails in your jurisdiction: _____

- D. Please mail copies of legislation, rules/regulations and/or policies that prohibit concurrent ATV use on groomed snowmobile trails in your area to: Trails Work Consulting, 4015 S. Brady Court, Sioux Falls, SD 57103, or send as e-mail attachments to Trailswork@aol.com

Thank you! Please skip to Part III.

- _____ **Yes**, our jurisdiction allows some level of concurrent ATV use on groomed snowmobile trails during the winter season.
- E. Total miles/kilometers of groomed snowmobile trails in your jurisdiction: _____
- F. Total miles/kilometers of groomed snowmobile trails that are open to concurrent snowmobile/ATV use in your jurisdiction: _____
- G. Total number of snowmobile trail systems in your jurisdiction: _____
- H. Total number of snowmobile trail systems that are open to concurrent snowmobile/ATV use in your jurisdiction: _____
- I. Please provide an estimate of the 'use level' on your trails that allow concurrent snowmobile/ATV use. If you have multiple areas with varying use levels, please provide multiple answers. Indicate use levels by using two different ratios: 1) snowmobile/ATV use in terms of heavy, moderate or minimal levels of overall use (example: moderate snowmobile/minimal ATV), and 2) in terms of percentage of estimated total use (example: 70% snowmobile/30% ATV):
If available, please provide total use statistics or estimates for each area (by name of area):
- J. What is the time period when concurrent snowmobile/ATV use is allowed (check one and specify dates/months/times): _____ same as snowmobile season _____ special season restrictions
Concurrent use is generally allowed from _____ to _____
Please provide additional information if further explanation is required regarding 'season of use' conditions or parameters (snow depth, temperatures, time of day, etc.):
- K. Please indicate how concurrent ATV use on groomed snowmobile trails is allowed in your area: (please check those applicable)
_____ legislation _____ rule/regulation _____ policy _____ no formal action to allow
- L. Please explain reason(s) why concurrent ATV use is allowed on groomed snowmobile trails in your jurisdiction:
- M. Please mail copies of legislation, rules/regulations and/or policies that allow concurrent ATV use on groomed snowmobile trails in your area to: Trails Work Consulting, 4015 S. Brady Court, Sioux Falls, SD 57103, or send as e-mail attachments to Trailswork@aol.com

Part II: If your jurisdiction allows any level of concurrent ATV use on groomed snowmobile trails during the winter season, please provide the following information as it may apply to your area:

- A. If available, please provide any information and statistics you may have regarding crashes on the trails that allow concurrent snowmobile/ATV use (total number of all [snowmobile and ATV] crashes reported, breakdown of all types of crashes, causes of all crashes, etc.). If applicable, please mail/e-mail full report to Trails Work Consulting:
- If available, provide statistics (with the same breakdown as above) regarding the total number of crashes that involved an ATV and also the total number of crashes documented between snowmobiles and ATVs:
- Please indicate if the crash rate is _____ about the same _____ higher _____ lower than crash rates on 'snowmobile-only' trails in your jurisdiction. Additional comments or observations about this:
- B. If available, please provide any information, statistics, and incident reports you may have regarding social conflicts on the trails that allow concurrent snowmobile/ATV use (total number of incidents reported, breakdown on types of incidents, causes of incidents, etc.):
- If available, provide statistics (with the same breakdown as above) regarding the total number of social conflict incidents that involved an ATV:
- Please indicate if the incident rate is _____ about the same _____ higher _____ lower than incident rates on 'snowmobile-only' trails in your jurisdiction. Additional comments or observations about this:

- C. Please provide details regarding any special management guidelines, policies, procedures, restrictions, practices, etc. used by your jurisdiction to manage concurrent snowmobile/ATV use:
- D. Please provide any case history information you believe may be beneficial for developing BMPs:
Mail to Trails Work Consulting, 4015 S. Brady Court, Sioux Falls, SD 57103, or send as e-mail attachments to Trailswork@aol.com

Part III: Off-season impacts from ATV use on historic snowmobile trail routes may occur regardless if the jurisdiction allows any level of concurrent ATV use on groomed snowmobile trails during the winter season. Please answer the following questions to help identify the degree of existing off-season impacts and potential BMPs for this issue.

- A. Does your jurisdiction currently experience off-season (spring, summer, and/or fall) impacts from ATV use on historic snowmobile trail routes? No (Thank you for your time, you have finished the survey!) Yes (please answer the remaining questions)
- B. Please indicate the types of off-season impacts from ATV use on historic snowmobile trail routes that you experience in your area (specify all that apply to your area by ranking/placing a number next to those impacts pertinent to your jurisdiction: 1 = greatest impact, 2 = next greatest impact, 3 = third greatest impact, through 4, 5, 6, 7, 8, 9, or 10 {or higher} = least impact, as it is pertinent to your area. If the impact is not an issue in your area, leave it blank.)
 - Private property trespass – there is landowner permission for only snowmobile season use
 - Public land use issues – there is agency permission for only winter use of the trail route
 - Severe resource damage from non-winter wheeled vehicle/ATV use during the off-season
 - Moderate resource damage from non-winter wheeled vehicle/ATV use during the off-season
 - Slight resource damage from non-winter wheeled vehicle/ATV use during the off-season
 - Conflicts with livestock grazing, gates left open, etc.
 - Harassment of livestock
 - Conflicts with wildlife production and rearing areas
 - Harassment of wildlife
 - Social conflicts with heavy non-motorized use of the trail route during the off-season
 - Conflicts with exclusive non-motorized use of the trail route during the off-season
 - Other (specify): _____
 - Other (specify): _____
- C. Please rate the same list of potential off-season impacts by indicating the severity of the problem in your jurisdiction (3 = an extreme problem, 2 = a major problem, 1 = a slight problem, 0 = not a problem. Please rate all potential impacts.)
 - Private property trespass – there is landowner permission for only snowmobile season use
 - Public land use issues – there is agency permission for only winter use of the trail route
 - Severe resource damage from non-winter wheeled vehicle use during the off-season
 - Moderate resource damage from non-winter wheeled vehicle/ATV use during the off-season
 - Slight resource damage from non-winter wheeled vehicle/ATV use during the off-season
 - Conflicts with livestock grazing, gates left open, etc.
 - Harassment of livestock
 - Conflicts with wildlife production and rearing areas
 - Harassment of wildlife
 - Social conflicts with heavy non-motorized use of the trail route during the off-season
 - Conflicts with exclusive non-motorized use of the trail route during the off-season
 - Other (specify): _____
 - Other (specify): _____
- D. Please provide detailed information regarding any special management guidelines, policies, procedures, restrictions, practices, etc. used by your jurisdiction to manage unauthorized off-season ATV use on snowmobile trail routes. Please mail to Trails Work Consulting, 4015 S. Brady Court, Sioux Falls, SD 57103, or send as e-mail attachments to Trailswork@aol.com **Thank You!**

APPENDIX C: Evaluation of ATV Use on Groomed Snowmobile Trails
FIELD STUDY REPORT FORM – COVER SHEET SAMPLE

Date _____ Field Study State/Provincial Code & Number _____

Location _____

Observer _____ Elevation _____ Time/Temperature (update temperature hourly):

Start: _____/_____/_____ _____/_____/_____ _____/_____/_____ _____/_____/_____
 _____/_____/_____ _____/_____/_____ _____/_____/_____ End: _____/_____/_____

Weather: Clear Cloudy/Overcast Partly Cloudy Sunny Partly Sunny Snow Rain
 Sleet Other _____ (check all that apply)

Wind Speed _____ Depth of Compacted Snow on Trail Base _____

Trail Aspect: Flat Uphill _____ % grade Downhill _____ % grade Other _____

Trail Conditions: Fresh Groomed – hard Fresh Groomed – soft Hard Pack - smooth Normal
 Lightly Moguled Heavily Moguled – Mogul Depth: 2” – 6” 6” – 12” 12” – 18” 18”+
 Other _____ (check all that apply)

New Snow on Groomed Trail Base: None Skiff ¼” – 2” 2” – 6” 6” – 12” 12” – 18” 18”+

Date/Time of Last Grooming _____ Grooming Equipment _____

Measuring Equipment: Distance _____

Depth _____

Other _____

Vehicle Information: Complete an information block for each vehicle used during the day of field testing and then use the Vehicle Code (A1, S1, etc.) to track that vehicle’s performance on each corresponding Daily Test Log.

ATV #1	Make:	Model:	Year:	License #:
Code: A1				
<input type="checkbox"/> 2WD <input type="checkbox"/> 4WD	Tire Size: Front - Rear -	Tire Brand/Model:	Tire Lug Depth:	Tire Pressure:
<input type="checkbox"/> Track Conversion	# Tires:	Tire Tread Design:	Transmission Type:	Engine cc:
	Track Type (if equipped):			# Passengers on:

Snowmobile #1	Make:	Model:	Year:	License #:
Code: S1				
Track Lug/ Paddle Height:	Track Length: Track Width:	Ski Type: <input type="checkbox"/> Metal <input type="checkbox"/> Composite/Plastic <input type="checkbox"/> Double Runner	Ski Carbide: <input type="checkbox"/> Yes <input type="checkbox"/> No	Engine cc: # Passengers on:

Date _____

Field Study State Code/Number _____

ATV #2	Make:	Model:	Year:	License #:
Code: A2				
<input type="checkbox"/> 2WD <input type="checkbox"/> 4WD	Tire Size: Front - Rear -	Tire Brand/Model:	Tire Lug Depth:	Tire Pressure:
<input type="checkbox"/> Track Conversion	# Tires:	Tire Tread Design:	Transmission Type:	Engine cc:
	Track Type (if equipped):			# Passengers on:

Snowmobile #2	Make:	Model:	Year:	License #:
Code: S2				
Track Lug/ Paddle Height:	Track Length:	Ski Type: <input type="checkbox"/> Metal <input type="checkbox"/> Composite/Plastic <input type="checkbox"/> Double Runner	Ski Carbide: <input type="checkbox"/> Yes <input type="checkbox"/> No	Engine cc:
	Track Width:			# Passengers on:

ATV #3	Make:	Model:	Year:	License #:
Code: A3				
<input type="checkbox"/> 2WD <input type="checkbox"/> 4WD	Tire Size: Front - Rear -	Tire Brand/Model:	Tire Lug Depth:	Tire Pressure:
<input type="checkbox"/> Track Conversion	# Tires:	Tire Tread Design:	Transmission Type:	Engine cc:
	Track Type (if equipped):			# Passengers on:

Snowmobile #3	Make:	Model:	Year:	License #:
Code: S3				
Track Lug/ Paddle Height:	Track Length:	Ski Type: <input type="checkbox"/> Metal <input type="checkbox"/> Composite/Plastic <input type="checkbox"/> Double Runner	Ski Carbide: <input type="checkbox"/> Yes <input type="checkbox"/> No	Engine cc:
	Track Width:			# Passengers on:

ATV #4	Make:	Model:	Year:	License #:
Code: A4				
<input type="checkbox"/> 2WD <input type="checkbox"/> 4WD	Tire Size: Front - Rear -	Tire Brand/Model:	Tire Lug Depth:	Tire Pressure:
<input type="checkbox"/> Track Conversion	# Tires:	Tire Tread Design:	Transmission Type:	Engine cc:
	Track Type (if equipped):			# Passengers on:

Snowmobile #4	Make:	Model:	Year:	License #:
Code: S4				
Track Lug/ Paddle Height:	Track Length:	Ski Type: <input type="checkbox"/> Metal <input type="checkbox"/> Composite/Plastic <input type="checkbox"/> Double Runner	Ski Carbide: <input type="checkbox"/> Yes <input type="checkbox"/> No	Engine cc:
	Track Width:			# Passengers on:

APPENDIX D: Evaluation of ATV Use on Groomed Snowmobile Trails – FIELD STUDY DAILY TEST LOG

Date _____ Field Study Code/Number _____ Unit of Measure: feet/inches meter/centimeters Vehicle Code _____

Trail Conditions: ___ Smooth ___ Moguled Mogul Depth: _____ Driver: _____

Start Time: _____ Start Temp: _____ End Time: _____ End Temp: _____

Vehicle Pass #	Slow/Normal Start		Normal Pass-By		Slow/Normal Stop		Average Pass-By Speed: _____
	Depth/Width	Distance	Depth/Width	Distance	Depth/Width	Distance	Observations:
1							
2							
3							
4							
5							
6							

Comments:

Vehicle Pass #	Aggressive Start		Aggressive Pass		Aggressive Stop		Average Pass-By Speed: _____
	Depth/Width	Distance	Depth/Width	Distance	Depth/Width	Distance	Observations:
1							
2							
3							
4							
5							
6							
7							
8							

Comments:

Vehicle Pass #	Normal Corner		Aggressive Corner		Corner/Curve		Average Normal Speed: _____	Average Aggressive Speed: _____
	Depth/Width	Distance	Depth/Width	Distance	Radius	Distance	Observations:	
1								
2								
3								
4								
5								
6								
7								
8								

Comments:

Date _____ Field Study Code/Number _____ Vehicle Code _____

Vehicle Pass #	Normal Hill		Aggressive Hill		Hill - Up		Average Normal Speed: _____ Average Aggressive Speed: _____ Observations:
	Depth/Width	Distance	Depth/Width	Distance	% Grade	Distance	
1							
2							
3							
4							
5							
6							

Comments:

Vehicle Pass #	Normal Hill		Aggressive Hill		Hill - Down		Average Normal Speed: _____ Average Aggressive Speed: _____ Observations:
	Depth/Width	Distance	Depth/Width	Distance	% Grade	Distance	
1							
2							
3							
4							
5							
6							

Comments:

Additional General Comments: