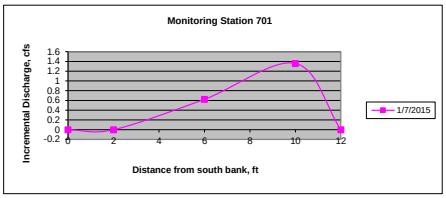
**U. S. Steel Minntac**
**NPDES/SDS Permit MN0057207**
**Monitoring Station 701**
Sandy River @ Hwy 53, 12' box culvert

**Date:** **1/7/2015**

| from South Bank (ft) | Total Depth (ft) | Ice Thickness (ft) | Effective Depth of Flow (ft) | 0.6 Depth (ft) | 625 Velocity (m/s) | 625 Velocity (fps) | Discharge (cfs) | Notes |
|---|---|---|---|---|---|---|---|---|
| 0 | 3.7 | 0.75 | 2.95 | | | | 0 | |
| 2 | 3.7 | 0.75 | 2.95 | 1.77 | ~~0.2~~ | 0 | 0 | 60% depth |
| 6 | 3.7 | 0.58333333 | 3.11667 | 1.87 | ~~0.4~~ | 0.05 | 0.62333 | 60% depth |
| 10 | 3.9 | 0.5 | 3.4 | 2.04 | ~~0.1~~ | 0.1 | 1.36 | 60% depth |
| 12 | 3.9 | 0.5 | 3.4 | | | | 0 | |

Total Discharge = **1.98333** cfs
890.12 gpm




**Date:** **4/1/2015** (1245)
**Stream Width:** 12 feet
**Staff Gauge Level:** n/a
**Field Crew:** PM, TN

| Segment Center (feet) | Segment Width (feet) | Segment Depth (feet) | Segment Area (sqft) | Depth - 20% (feet) | Depth - 60% (feet) | Depth - 80% (feet) | Velocity at (Depth - 20%) (fps) | Velocity at (Depth - 60%) (fps) | Velocity at (Depth - 80%) (fps) | Average Velocity (fps) | Segment Flow (cfs) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | | 0.000 | 0 |
| 0.5 | 1.0 | 2.15 | 2.15 | 1.72 | 0.86 | 0.43 | | 0.00 | | 0.00 | 0.000 | -2.15 |
| 2 | 2.0 | 2.55 | 5.10 | 2.04 | 1.02 | 0.51 | | 0.00 | | 0.00 | 0.000 | -2.55 |
| 4 | 2.0 | 2.55 | 5.10 | 2.04 | 1.02 | 0.51 | | 0.00 | | 0.00 | 0.000 | -2.55 |
| 6 | 1.5 | 2.55 | 3.83 | 2.04 | 1.02 | 0.51 | | 0.00 | | 0.00 | 0.000 | -2.55 |
| 7 | 1.0 | 2.65 | 2.65 | 2.12 | 1.06 | 0.53 | | 0.00 | | 0.00 | 0.000 | -2.65 |
| 8 | 1.0 | 2.7 | 2.70 | 2.16 | 1.08 | 0.54 | | 0.20 | | 0.20 | 0.540 | -2.7 |
| 9 | 1.0 | 2.6 | 2.60 | 2.08 | 1.04 | 0.52 | | 0.30 | | 0.30 | 0.780 | -2.6 |
| 10 | 1.5 | 2.65 | 3.98 | 2.12 | 1.06 | 0.53 | | 0.20 | | 0.20 | 0.795 | -2.65 |
| 11.5 | 1.0 | 2.3 | 2.30 | 1.84 | 0.92 | 0.46 | | 0.40 | | 0.40 | 0.920 | -2.3 |
| 12 | | | | | | | | | | | 0.000 | 0 |

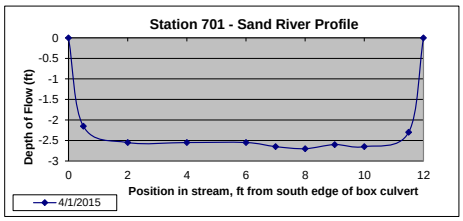
**Σ (sqft) =** **30.4**

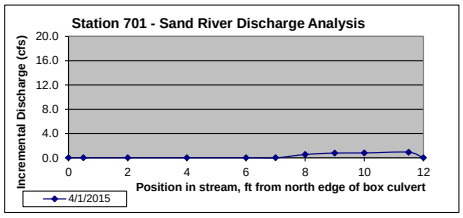
**Total Flow (cfs):** **3.04**

**Total Flow (gpm):** **1362.11**

**Comments:** Measurements were taken from the south side of the culvert, proceeding to the north.

1.9614355 MGD




**Date:** **5/6/2015** (1315)
**Stream Width:** 12 feet
**Staff Gauge Level:** n/a
**Field Crew:** TAM, PM, TN

| Segment Center (feet) | Segment Width (feet) | Segment Depth (feet) | Segment Area (sqft) | Depth - 20% (feet) | Depth - 60% (feet) | Depth - 80% (feet) | Velocity at (Depth - 20%) (fps) | Velocity at (Depth - 60%) (fps) | Velocity at (Depth - 80%) (fps) | Average Velocity (fps) | Segment Flow (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | | 0.000 |
| 0.5 | 1.0 | 3.5 | 3.50 | 2.80 | 1.40 | 0.70 | | 0.00 | | 0.00 | 0.000 |
| 2 | 2.0 | 3.6 | 7.20 | 2.88 | 1.44 | 0.72 | | 0.00 | | 0.00 | 0.000 |
| 4 | 2.0 | 3.6 | 7.20 | 2.88 | 1.44 | 0.72 | | 0.20 | | 0.20 | 1.440 |
| 6 | 2.0 | 3.8 | 7.60 | 3.04 | 1.52 | 0.76 | | 0.50 | | 0.50 | 3.800 |
| 8 | 2.0 | 3.9 | 7.80 | 3.12 | 1.56 | 0.78 | | 0.50 | | 0.50 | 3.900 |
| 10 | 2.0 | 3.7 | 7.40 | 2.96 | 1.48 | 0.74 | | 0.10 | | 0.10 | 0.740 |
| 11.5 | 1.0 | 3.8 | 3.80 | 3.04 | 1.52 | 0.76 | | 0.10 | | 0.10 | 0.380 |
| 12 | | | | | | | | | | | 0.000 |

**Σ (sqft) =** **44.5**

**Total Flow (cfs):** **10.26**

**Total Flow (gpm):** **4604.69**

**Comments:** Measurements were taken from the south side of the culvert, proceeding to the north.

6.6307507 MGD

**Date:** **5/14/2015** (1230)
**Stream Width:** 12 feet
**Staff Gauge Level:** n/a
**Field Crew:** TAM, M. Kelly, S. Koski

| Segment Center (feet) | Segment Width (feet) | Segment Depth (feet) | Segment Area (sqft) | Depth - 20% (feet) | Depth - 60% (feet) | Depth - 80% (feet) | Velocity at (Depth - 20%) (fps) | Velocity at (Depth - 60%) (fps) | Velocity at (Depth - 80%) (fps) | Average Velocity (fps) | Segment Flow (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | | 0.000 |
| 0.5 | 1.0 | 3.9 | 3.90 | 3.12 | 1.56 | 0.78 | 0.10 | | 0.10 | 0.10 | 0.390 |
| 2 | 2.0 | 4.35 | 8.70 | 3.48 | 1.74 | 0.87 | 0.30 | | 0.50 | 0.40 | 3.480 |
| 4 | 2.0 | 4.4 | 8.80 | 3.52 | 1.76 | 0.88 | 1.00 | | 0.60 | 0.80 | 7.040 |
| 6 | 2.0 | 4.45 | 8.90 | 3.56 | 1.78 | 0.89 | 1.10 | | 1.10 | 1.10 | 9.790 |
| 8 | 2.0 | 4.5 | 9.00 | 3.60 | 1.80 | 0.90 | 1.10 | | 1.40 | 1.25 | 11.250 |
| 10 | 2.0 | 4.5 | 9.00 | 3.60 | 1.80 | 0.90 | 0.80 | | 0.70 | 0.75 | 6.750 |
| 11.5 | 1.0 | 3.9 | 3.90 | 3.12 | 1.56 | 0.78 | 0.40 | | 0.70 | 0.55 | 2.145 |
| 12 | | | | | | | | | | | 0.000 |

**Σ (sqft) =** **52.2**

**Total Flow (cfs):** **40.85**

**Total Flow (gpm):** **18331.24**

**Comments:** Measurements were taken from the south side of the culvert, proceeding to the north.

26.39698 MGD

**Date:** **6/3/2015** (0900)
**Stream Width:** 12 feet
**Staff Gauge Level:** n/a
**Field Crew:** TAM, PM

| Segment Center | Segment Width | Segment Depth | Segment Area | Depth - 20% | Depth - 60% | Depth - 80% | Velocity at (Depth - 20%) | Velocity at (Depth - 60%) | Velocity at (Depth - 80%) | Average Velocity | Segment Flow |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (feet) | (feet) | (feet) | (sqft) | (feet) | (feet) | (feet) | (fps) | (fps) | (fps) | (fps) | (cfs) |
| 0 | | | | | | | | | | | 0.000 |
| 0.5 | 1.0 | 3.6 | 3.60 | 2.88 | 1.44 | 0.72 | 0.00 | | 0.10 | 0.05 | 0.180 |
| 2 | 2.0 | 3.7 | 7.40 | 2.96 | 1.48 | 0.74 | 0.20 | | 0.10 | 0.15 | 1.110 |
| 4 | 2.0 | 3.9 | 7.80 | 3.12 | 1.56 | 0.78 | 0.50 | | 0.15 | 0.33 | 2.535 |
| 6 | 2.0 | 4.05 | 8.10 | 3.24 | 1.62 | 0.81 | 0.50 | | 0.30 | 0.40 | 3.240 |
| 8 | 2.0 | 4.1 | 8.20 | 3.28 | 1.64 | 0.82 | 0.60 | | 0.90 | 0.75 | 6.150 |
| 10 | 2.0 | 4 | 8.00 | 3.20 | 1.60 | 0.80 | 0.50 | | 1.10 | 0.80 | 6.400 |
| 11.5 | 1.0 | 3.5 | 3.50 | 2.80 | 1.40 | 0.70 | 0.50 | | 0.70 | 0.60 | 2.100 |
| 12 | | | | | | | | | | | 0.000 |

**Σ (sqft) =** **46.6**

**Total Flow (cfs):** **21.72**

**Total Flow (gpm):** **9745.69**

**Comments:** Measurements were taken from the south side of the culvert, proceeding to the north.

14.033796 MGD

**Date:** **7/1/2015** (0930)
**Stream Width:** 12 feet
**Staff Gauge Level:** n/a
**Field Crew:** TAM, PM

| Segment Center | Segment Width | Segment Depth | Segment Area | Depth - 20% | Depth - 60% | Depth - 80% | Velocity at (Depth - 20%) | Velocity at (Depth - 60%) | Velocity at (Depth - 80%) | Average Velocity | Segment Flow |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (feet) | (feet) | (feet) | (sqft) | (feet) | (feet) | (feet) | (fps) | (fps) | (fps) | (fps) | (cfs) |
| 0 | | | | | | | | | | | 0.000 |
| 0.5 | 1.0 | 3.2 | 3.20 | 2.56 | 1.28 | 0.64 | 0.10 | | 0.05 | 0.08 | 0.240 |
| 2 | 2.0 | 3.7 | 7.40 | 2.96 | 1.48 | 0.74 | 0.05 | | 0.05 | 0.05 | 0.370 |
| 4 | 2.0 | 3.7 | 7.40 | 2.96 | 1.48 | 0.74 | 0.30 | | 0.20 | 0.25 | 1.850 |
| 6 | 2.0 | 3.9 | 7.80 | 3.12 | 1.56 | 0.78 | 0.70 | | 0.50 | 0.60 | 4.680 |
| 8 | 2.0 | 3.8 | 7.60 | 3.04 | 1.52 | 0.76 | 0.50 | | 1.00 | 0.75 | 5.700 |
| 10 | 2.0 | 3.8 | 7.60 | 3.04 | 1.52 | 0.76 | 0.60 | | 0.80 | 0.70 | 5.320 |
| 11.5 | 1.0 | 3.2 | 3.20 | 2.56 | 1.28 | 0.64 | 0.50 | | 0.80 | 0.65 | 2.080 |
| 12 | | | | | | | | | | | 0.000 |

**Σ (sqft) =** **44.2**

**Total Flow (cfs):** **20.24**

**Total Flow (gpm):** **9083.71**

**Comments:** Measurements were taken from the south side of the culvert, proceeding to the north.

13.080545 MGD

**Date:** **8/5/2015** (1155)
**Stream Width:** 12 feet
**Staff Gauge Level:** n/a
**Field Crew:** TAM, BF

| Segment Center | Segment Width | Segment Depth | Segment Area | Depth - 20% | Depth - 60% | Depth - 80% | Velocity at (Depth - 20%) | Velocity at (Depth - 60%) | Velocity at (Depth - 80%) | Average Velocity | Segment Flow |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (feet) | (feet) | (feet) | (sqft) | (feet) | (feet) | (feet) | (fps) | (fps) | (fps) | (fps) | (cfs) |
| 0 | | | | | | | | | | | 0.000 |
| 0.5 | 1.0 | 2.5 | 2.50 | 2.00 | 1.00 | 0.50 | 0.00 | | 0.00 | 0.00 | 0.000 |
| 2 | 2.0 | 2.8 | 5.60 | 2.24 | 1.12 | 0.56 | 0.00 | | 0.02 | 0.01 | 0.056 |
| 4 | 2.0 | 2.8 | 5.60 | 2.24 | 1.12 | 0.56 | 0.02 | | 0.02 | 0.02 | 0.112 |
| 6 | 2.0 | 2.85 | 5.70 | 2.28 | 1.14 | 0.57 | 0.07 | | 0.07 | 0.07 | 0.399 |
| 8 | 2.0 | 2.95 | 5.90 | 2.36 | 1.18 | 0.59 | 0.29 | | 0.23 | 0.26 | 1.534 |
| 10 | 2.0 | 2.9 | 5.80 | 2.32 | 1.16 | 0.58 | 0.25 | | 0.27 | 0.26 | 1.508 |
| 11.5 | 1.0 | 2.4 | 2.40 | 1.92 | 0.96 | 0.48 | 0.24 | | 0.43 | 0.34 | 0.804 |
| 12 | | | | | | | | | | | 0.000 |

**Σ (sqft) =** **33.5**

**Total Flow (cfs):** **4.41**

**Total Flow (gpm):** **1980.55**

**Comments:** Measurements were taken from the south side of the culvert, proceeding to the north.

2.8519983 MGD

**Date:** **9/9/2015** (1130)
**Stream Width:** 12 feet
**Staff Gauge Level:** n/a
**Field Crew:** TAM, PM

| Segment Center | Segment Width | Segment Depth | Segment Area | Depth - 20% | Depth - 60% | Depth - 80% | Velocity at (Depth - 20%) | Velocity at (Depth - 60%) | Velocity at (Depth - 80%) | Average Velocity | Segment Flow |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (feet) | (feet) | (feet) | (sqft) | (feet) | (feet) | (feet) | (fps) | (fps) | (fps) | (fps) | (cfs) |
| 0 | | | | | | | | | | | 0.000 |
| 0.5 | 1.0 | 3 | 3.00 | 2.40 | 1.20 | 0.60 | 0.10 | | 0.10 | 0.10 | 0.300 |
| 2 | 2.0 | 3.8 | 7.60 | 3.04 | 1.52 | 0.76 | 0.00 | | 0.05 | 0.03 | 0.190 |
| 4 | 2.0 | 3.9 | 7.80 | 3.12 | 1.56 | 0.78 | 0.05 | | 0.40 | 0.23 | 1.755 |
| 6 | 2.0 | 3.9 | 7.80 | 3.12 | 1.56 | 0.78 | 0.10 | | 0.50 | 0.30 | 2.340 |
| 8 | 2.0 | 3.9 | 7.80 | 3.12 | 1.56 | 0.78 | 0.30 | | 0.60 | 0.45 | 3.510 |
| 10 | 2.0 | 3.9 | 7.80 | 3.12 | 1.56 | 0.78 | 0.40 | | 0.80 | 0.60 | 4.680 |
| 11.5 | 1.0 | 3.1 | 3.10 | 2.48 | 1.24 | 0.62 | 0.50 | | 0.90 | 0.70 | 2.170 |
| 12 | | | | | | | | | | | 0.000 |

**Σ (sqft) =** **44.9**

**Total Flow (cfs):** **14.95**

**Total Flow (gpm):** **6707.32**

**Comments:** Measurements were taken from the south side of the culvert, proceeding to the north.

9.658535 MGD

**Date:** **10/2/2015** (*1130*)
**Stream Width:** 12 feet
**Staff Gauge Level:** n/a
**Field Crew:** TAM, BF

| Segment Center | Segment Width | Segment Depth | Segment Area | Depth - 20% | Depth - 60% | Depth - 80% | Velocity at (Depth - 20%) | Velocity at (Depth - 60%) | Velocity at (Depth - 80%) | Average Velocity | Segment Flow |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (feet) | (feet) | (feet) | (sqft) | (feet) | (feet) | (feet) | (fps) | (fps) | (fps) | (fps) | (cfs) |
| 0 | | | | | | | | | | | 0.000 |
| 0.5 | 1.0 | 2.85 | 2.85 | 2.28 | 1.14 | 0.57 | 0.02 | | 0.03 | 0.03 | 0.071 |
| 2 | 2.0 | 3.2 | 6.40 | 2.56 | 1.28 | 0.64 | 0.03 | | 0.05 | 0.04 | 0.256 |
| 4 | 2.0 | 3.2 | 6.40 | 2.56 | 1.28 | 0.64 | 0.21 | | 0.18 | 0.20 | 1.248 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 2.0 | 3.3 | 6.60 | 2.64 | 1.32 | 0.66 | 0.19 | 0.50 | 0.35 | 2.277 |
| 8 | 2.0 | 3.35 | 6.70 | 2.68 | 1.34 | 0.67 | 0.53 | 0.53 | 0.53 | 3.551 |
| 10 | 2.0 | 3.35 | 6.70 | 2.68 | 1.34 | 0.67 | 0.82 | 0.58 | 0.70 | 4.690 |
| 11.5 | 1.0 | 2.8 | 2.80 | 2.24 | 1.12 | 0.56 | 0.81 | 0.45 | 0.63 | 1.764 |
| 12 | | | | | | | | | | 0.000 |

**Σ (sqft) =** **38.5**

**Total Flow (cfs):** **13.86**

**Total Flow (gpm):** **6219.13**

**Comments:** Measurements were taken from the south side of the culvert, proceeding to the north.

8.9555527 MGD

**Date:** **10/8/2015** (1345)
**Stream Width:** 12 feet
**Staff Gauge Level:** n/a
**Field Crew:** TAM, SK, CJ

| Segment Center | Segment Width | Segment Depth | Segment Area | Depth - 20% | Depth - 60% | Depth - 80% | Velocity at (Depth - 20%) | Velocity at (Depth - 60%) | Velocity at (Depth - 80%) | Average Velocity | Segment Flow |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (feet) | (feet) | (feet) | (sqft) | (feet) | (feet) | (feet) | (fps) | (fps) | (fps) | (fps) | (cfs) |
| 0 | | | | | | | | | | | 0.000 |
| 0.5 | 1.0 | 2.5 | 2.50 | 2.00 | 1.00 | 0.50 | | 0.00 | | 0.00 | 0.000 |
| 2 | 2.0 | 3.15 | 6.30 | 2.52 | 1.26 | 0.63 | | 0.00 | | 0.00 | 0.000 |
| 4 | 2.0 | 3.2 | 6.40 | 2.56 | 1.28 | 0.64 | 0.05 | | 0.05 | 0.05 | 0.320 |
| 6 | 2.0 | 3.2 | 6.40 | 2.56 | 1.28 | 0.64 | 0.20 | | 0.20 | 0.20 | 1.280 |
| 8 | 2.0 | 3.2 | 6.40 | 2.56 | 1.28 | 0.64 | 0.20 | | 0.50 | 0.35 | 2.240 |
| 10 | 2.0 | 3.2 | 6.40 | 2.56 | 1.28 | 0.64 | 0.20 | | 0.70 | 0.45 | 2.880 |
| 11.5 | 1.0 | 2.5 | 2.50 | 2.00 | 1.00 | 0.50 | | 0.20 | | 0.20 | 0.500 |
| 12 | | | | | | | | | | | 0.000 |

**Σ (sqft) =** **36.9**

**Total Flow (cfs):** **7.22**

**Total Flow (gpm):** **3240.34**

**Comments:** Measurements were taken from the south side of the culvert, proceeding to the north.

4.6660838 MGD

**Date:** **11/6/2015** (0900)
**Stream Width:** 12 feet
**Staff Gauge Level:** n/a
**Field Crew:** TAM

| Segment Center | Segment Width | Segment Depth | Segment Area | Depth - 20% | Depth - 60% | Depth - 80% | Velocity at (Depth - 20%) | Velocity at (Depth - 60%) | Velocity at (Depth - 80%) | Average Velocity | Segment Flow |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (feet) | (feet) | (feet) | (sqft) | (feet) | (feet) | (feet) | (fps) | (fps) | (fps) | (fps) | (cfs) |
| 0 | | | | | | | | | | | 0.000 |
| 0.5 | 1.0 | 3.1 | 3.10 | 2.48 | 1.24 | 0.62 | 0.00 | | 0.00 | 0.00 | 0.000 |
| 2 | 2.0 | 3.75 | 7.50 | 3.00 | 1.50 | 0.75 | 0.20 | | 0.10 | 0.15 | 1.125 |
| 4 | 2.0 | 3.8 | 7.60 | 3.04 | 1.52 | 0.76 | 0.40 | | 0.10 | 0.25 | 1.900 |
| 6 | 2.0 | 3.9 | 7.80 | 3.12 | 1.56 | 0.78 | 0.70 | | 0.20 | 0.45 | 3.510 |
| 8 | 2.0 | 3.9 | 7.80 | 3.12 | 1.56 | 0.78 | 0.80 | | 0.90 | 0.85 | 6.630 |
| 10 | 2.0 | 3.9 | 7.80 | 3.12 | 1.56 | 0.78 | 0.40 | | 1.00 | 0.70 | 5.460 |
| 11.5 | 1.0 | 3.1 | 3.10 | 2.48 | 1.24 | 0.62 | 0.20 | | 0.70 | 0.45 | 1.395 |
| 12 | | | | | | | | | | | 0.000 |

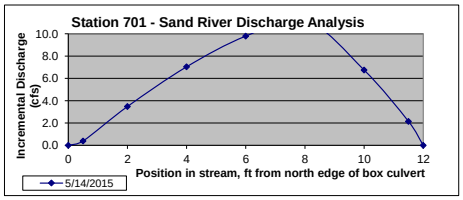
**Σ (sqft) =** **44.7**

**Total Flow (cfs):** **20.02**

**Total Flow (gpm):** **8984.98**

**Comments:** Measurements were taken from the south side of the culvert, proceeding to the north.

12.938365 MGD


Station 701 - Sand River Discharge Analysis
Incremental Discharge (cfs)
10.0
8.0
6.0
4.0
2.0
0.0
0
2
4
6
8
10
12
Position in stream, ft from north edge of box culvert
5/14/2015