

MBT™ Treatment Technology Pilot Study Results: Leachable PFAS in Solid Waste (August – September 2020)



MBT – Treatment and Pilot Projects

1. Treatability – Bench Viability (500g to 2Kg)
 - a) Eastern MI Soil
 - b) Western MI Soil

2. Pilot/Field Demonstration (~70 Kg)
 - a) Confidential Site Soil

MBT Bench & Engineering-Scale Treatability Studies

1. PFAS leachability reduction from host soil, sediments, other solid matrices
2. USEPA Test Methods:
 - a) Method 1311 (TCLP – lab grade reagents)
 - b) Method 1312 (SPLP – acid rain from lab grade reagents)
 - c) Modified Method 1312 (DI Water)
 - d) Modified Method 1312 (PFAS impacted groundwater)
 - e) Modified Method 1312 (Subtitle D landfill leachate containing PFAS)

MBT PFAS Leachability Viability Results:

Eastern Michigan Site Soil – **Method 1311** (TCLP – Synthetic Landfill Leachate)

| MBT Treatment Results of PFAS Telomers in Flint Michigan Soil | | | | | | | | |
|---|----------------|---------------------------------------|--------------|--------------------------|----------------------|----------------------|----------------------|----------------------|
| Soil Provider: | | Job Site Services, Inc., Bay City, MI | | | | | | |
| PFAS in USEPA Method 1311 TCLP Extract - MS Semi-volatiles (EPA 537M BY ID) | | | | | | | | |
| Treatment Regime: Matrix: | | | | Untreated <u>Soil</u> | MBT-1 <u>Soil</u> | MBT-2 <u>Soil</u> | MBT-3 <u>Soil</u> | MBT-4 <u>Soil</u> |
| <u>PFAS Telomere</u> | <u>Acronym</u> | <u>Fluorinated C Atoms</u> | <u>Units</u> | | | | | |
| Perfluorohexanoic acid | PFHXA | C ₆ | ug/l | 0.00415 J | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| Perfluoroheptanoic acid | PFHpA | C ₇ | ug/l | <0.0040 | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| Perfluorooctanoic acid | PFOA | C ₈ | ug/l | <0.0040 | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| Perfluorononanoic acid | PFNA | C ₉ | ug/l | <0.0040 | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| Perfluorodecanoic acid | PFDA | C ₁₀ | ug/l | <0.0040 | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| Perfluoroundecanoic acid | PFUnA | C ₁₁ | ug/l | <0.0040 | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| Perfluorododecanoic acid | PFDOA | C ₁₂ | ug/l | <0.0040 | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| Perfluorotridecanoic acid | PFTriA | C ₁₃ | ug/l | <0.0040 | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| Perfluorotetradecanoic acid | PFTeA | C ₁₄ | ug/l | <0.0040 | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| Perfluorobutanesulfonic acid | PFBA | C ₄ | ug/l | <0.0040 | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| Perfluorohexanesulfonic acid | PFHxS | C₆ | ug/l | 0.0143 | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| Perfluorooctanesulfonic acid | PFOS | C₈ | ug/l | 0.105 | <0.0040 | <0.0040 | <0.0040 | 0.0167 |

MBT processing applied in four (4) different regimens: MBT-1, 2, 3, and 4

MBT is the patent-pending treatment technology owned by HMR Solutions, Inc. of Brooklyn, NY for leachable heavy metals, PFAS, and other constituents in soil, sediments, and other solid waste.

Analyses by SGS, Orlando FL

MBT PFAS Leachability Viability Results:

Western Michigan Site Soil – **Method 1311** (TCLP – Synthetic Landfill Leachate)

| PFAS Leachability: Method 1311 (TCLP) | | | | | | |
|---------------------------------------|--|--|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|
| | UNTREATED Soil | | MBT TREATED Soil | | | |
| | Totals in Soil (avg.) (ng/Kg) | Totals in TCLP Extract (ng/L) | T-1 Soil Extract (ng/L) | T-2 Soil Extract (ng/L) | T-3 Soil Extract (ng/L) | T-4 Soil Extract (ng/L) |
| <u>Telomere</u> | | | | | | |
| PFBA | 264 | 50,000 | 49,000 | 50,000 | <50 | <50 |
| PFOA | 536 | 4,400 | 1,800 | 1,000 | <10 | <10 |
| PFDA | 1,175 | <50 | <50 | <50 | <50 | <50 |
| PFDoA | 394 | <50 | <50 | <50 | <50 | <50 |
| PFTeA | 1270 | <50 | <50 | <50 | <50 | <50 |
| PFOS | 29,600 | 1,700 | 1,500 | 630 | <10 | <10 |
| PFNS | 346 | <50 | <50 | <50 | <50 | <50 |
| PFDS | 765 | <50 | <50 | <50 | <10 | <10 |
| PFOSA | 6265 | <50 | 20 | <50 | <50 | <50 |
| EtFOSSA | 4,055 | 62 | <50 | <50 | <50 | <50 |

MBT PFAS Leachability Viability Results:

Western Michigan Site Soil – **Modified Method 1312**

(Actual Subtitle D Landfill Leachate Extraction Fluid)

| PFAS Leachability: (Modified) Method 1312 with Subtitle D Landfill Leachate Extraction Fluid | | | | | | | |
|--|-------------------------------------|--|-----------------------------------|------------------------------|------------------------|------------------------|------------------------|
| | | UNTREATED Soil and Subtitle D Landfill Leachate | | | MBT TREATED Soil | | |
| | | Totals in Soil (avg.) | Totals in Landfill Leachate | Totals in Soil Extract | T-2 Soil Extract | T-3 Soil Extract | T-4 Soil Extract |
| <u>Telomere</u> | <u>Chemical Name</u> | <u>(ng/Kg)</u> | <u>(ng/L)</u> | <u>(ng/L)</u> | <u>(ng/L)</u> | <u>(ng/L)</u> | <u>(ng/L)</u> |
| PFBA | Perfluorobutanoic Acid | 264 | 1,900 | 1,800 | 1,500 | 1,500 | 1,300 |
| PFOA | Perfluorooctanoic Acid | 536 | 680 | 490 | 200 | 170 | 110 |
| PFDA | Perfluorodecanoic Acid | 1,175 | 230 | 57 | <50 | <50 | <50 |
| PFDoA | Perfluorododenoic Acid | 394 | <50 | <50 | <50 | <50 | <50 |
| PFTeA | Perfluortetradecanoic Acid | 1270 | <50 | 28 | <50 | <50 | <50 |
| PFOS | Perfluorooctanesulfonic Acid | 29,600 | 450 | <10 | 52 | 38 | 33 |
| PFNS | Perfluorononanesulfonic Acid | 346 | <50 | <50 | <50 | <50 | <50 |
| PFDS | Perfluorodecanesulfonic Acid | 765 | <10 | <10 | <10 | <10 | <10 |
| PFOSA | Perfluorooctanesulfonamide | 6265 | <10 | 28 | <10 | <10 | <10 |
| EtFOSSA | N-Ethylperfluorooctane | 4,055 | <10 | <50 | <50 | <50 | <50 |

MBT PFAS Leachability Viability Results:

Western Michigan Site Soil – *Modified Method 1312*

(Actual Site Groundwater Extraction Fluid)

| PFAS Leachability: (MODIFIED) Method 1312 (Site Groundwater Extraction Fluid) | | | | | |
|---|--|---|--|----------------------------------|----------------------------------|
| | UNTREATED Soil and Groundwater | | | MBT TREATED Soil | |
| | Totals in Soil (avg.) (ng/Kg) | Totals in Groundwater Extract (ng/L) | Totals in Soil Extract (ng/L) | T-2 Soil Extract (ng/L) | T-4 Soil Extract (ng/L) |
| <u>Telomere</u> | | | | | |
| PFBA | 264 | 640 | 620 | 144 | 144 |
| PFOA | 536 | 100,000 | 94,000 | 220 | 89 |
| PFNA | <0.26 | 86 | 70 | <10 | <10 |
| PFDA | 1,175 | 96 | 57 | <50 | <50 |
| PFDoA | 394 | <50 | <50 | <50 | <50 |
| PFTeA | 1270 | <50 | <50 | <50 | <50 |
| PFOS | 29,600 | 390,000 | 190,000 | 230 | 121 |
| PFNS | 346 | <50 | <50 | <50 | <50 |
| PFDS | 765 | <10 | <10 | <10 | <10 |
| PFOSA | 6,265 | 63 | 120 | <10 | <10 |
| EtFOSSA | 4,055 | <50 | 140 | <50 | <50 |

MBT – Pilot

Confidential Site Source - August 2020

- Untreated material collected by Yost Brothers (8/27/2020)
 - No characterization data available
 - PFAS indicated to be @ ~800,000 ng/Kg
 - MBT treatment regimes designed for 1,000,000 ng/Kg
 - ~150 lbs. treated (MBT-1 & MBT-2)
- Mortar mixer batch treatment
- MBT reagents and water for Mixing
 - MBT-1 and MBT-2 reagent systems differentiate between organic and mineral based materials
- Reactive Mass – expansive in mixer and sample containers
- All treatments observed and sampled by FTCH (8/28/2020)
- Sample Duplicate Splits provided to YB
- Analyses by FTCH (Trace/Fibertec) and YB (ALS Environmental)



MBT – Pilot

Confidential Site Source, MI

MBT Processed Material

Treated: August 28, 2020

Mortar Mixer:

Post-MBT Treatment



MBT – Pilot

Confidential Site Source

Untreated Control

Treated: August 28, 2020

FTCH Lab = Trace/Fibertec

YB Lab = ALS Environmental

| <u>PFAS Telomer</u> | <u>Chemical Name</u> | <u>C Atoms</u> | UNTREATED: CONTROL | | | |
|------------------------------------|---|----------------|-----------------------------------|---------------|-----------------------------------|---------------|
| | | | Yost Brothers (ALS) | | FTCH (Fibertec/Trace) | |
| | | | TOTALS (dry wt) ng/Kg (dry-wt) | TCLP ng/L | TOTALS (dry wt) ng/Kg (dry-wt) | TCLP ng/L |
| PFBA | Perfluorobutanoic Acid | C4 | <150 | <49 | 140 | 18 |
| PFPeA | Perfluoropentanoic Acid | C5 | 170 | <49 | 160 | 13 |
| PFHxA | Perfluorohexanoic Acid | C6 | 350 | <49 | 340 | 21 |
| PFHpA | Perfluoroheptanoic Acid | C7 | 490 | <49 | 430 | 20 |
| PFOA | Perfluorooctanoic Acid | C8 | 9,400 | 340 | 12,000 | 350 |
| PFNA | Perfluorononanoic Acid | C9 | 270 | 30 | 1,100 | 11 |
| PFDA | Perfluorodecanoic Acid | C10 | 23,000 | 190 | 1,400 | <10 |
| PFUnA | Perfluoroundecanoic Acid | C11 | 2,200,000 | 3,800 | 2,800,000 | <10 |
| PFDoA | Perfluorododenoic Acid | C12 | 12,000 | <49 | <30 | <10 |
| PFTriA | Perfluorotridecanoic Acid | C13 | 990,000 | 130 | 1,200,000 | <20 |
| PFTeA | Perfluortetradecanoic Acid | C14 | <150 | <49 | <120 | <20 |
| PFBS | Perfluorobutanesulfonic Acid | C4 | 79 | <9.8 | 70 | <10 |
| PFPeS | Perfluoropentanesulfonic Acid | C5 | 1,109 | <9.8 | 130 | 11 |
| PFHxS | Perfluorohexanesulfonic Acid | C6 | 1,900 | 100 | 2,200 | 110 |
| PFHpS | Perfluoroheptanesulfonic Acid | C7 | 7,500 | 210 | 8,900 | 160 |
| PFOS | Perfluorooctanesulfonic Acid | C8 | 6,800,000 | 80,000 | 10,000,000 | 32,000 |
| PFNS | Perfluorononanesulfonic Acid | C9 | 32,000 | 81 | 57,000 | 25 |
| PFDS | Perfluorodecanesulfonic Acid | C10 | 45,000 | 23 | 61,000 | <10 |
| FtSA 4:2 | Fluorotelomer Sulfonic Acid 4:2 | C6 | <150 | <49 | <30 | <10 |
| FtSA 6:2 | Fluorotelomer Sulfonic Acid 6:2 | C8 | <150 | <49 | <30 | <10 |
| FtSA 8:2 | Fluorotelomer Sulfonic Acid 8:2 | C10 | <150 | <49 | <30 | <10 |
| PFOSA | Perfluorooctanesulfonamide | C8 | 140,000 | 160 | 180,000 | 39 |
| N-EtFOSSA | N-Ethylperfluorooctanesulfonic amidoacetic Acid | C12 | 5,300,000 | 5,300 | 3,300,000 | 200 |
| N-MeFOSAA | N-Methylperfluorooctanesulfonic amidoacetic Acid | C11 | 2,200 | <49 | 2,900 | <10 |
| F-53BMin | 11Cl-Pf3OUds | C10 | <29 | <9.8 | NR | NR |
| ADONA | 4,8-Doxa-3H-perfluorononanoic Acid | C8 | <29 | <9.8 | NR | NR |
| F-53BMaj | 9Cl-PF3ONS | C8 | <29 | <9.8 | NR | NR |
| --- | Hexafluoropropylene | C3 | <150 | <49 | NR | NR |
| Summation of PFOA : | | | 6,809,400 | 80,340 | 10,012,000 | 32,350 |
| Summation of PFAS Telomere Totals: | | | 15,565,468 | 90,364 | 17,627,770 | 32,978 |

MBT – Pilot

Confidential Site Source

MBT – Treatment #1

Treated: August 28, 2020

| <u>PFAS Telomers</u> | <u>Chemical Name</u> | <u>C Atoms</u> | TREATED: MBT-1 | | | |
|--|---|----------------|---|----------------------------|-------------------------------|----------------------------|
| | | | Yost Brothers (ALS) | | FTCH (Fibertec/Trace) | |
| | | | <u>TOTALS (dry wt)</u> <u>ng/Kg (dry-wt)</u> | <u>TCLP</u> <u>ng/L</u> | <u>TOTALS</u> <u>ng/Kg</u> | <u>TCLP</u> <u>ng/L</u> |
| PFHpA | Perfluoroheptanoic Acid | C7 | 190 | <50 | NA | <10 |
| PFOA | Perfluorooctanoic Acid | C8 | 3,100 | 12 | | 35 |
| PFNA | Perfluorononanoic Acid | C9 | 130 | <10 | | <10 |
| PFDA | Perfluorodecanoic Acid | C10 | 12,000 | 61 | | <10 |
| PFUnA | Perfluoroundecanoic Acid | C11 | 1,600,000 | 2,800 | | <10 |
| PFDoA | Perfluorododenoic Acid | C12 | 10,000 | <50 | | <10 |
| PFTriA | Perfluorotridecanoic Acid | C13 | 730,000 | 160 | | <20 |
| PFHxS | Perfluorohexanesulfonic Acid | C6 | 580 | <50 | | <20 |
| PFHpS | Perfluoroheptanesulfonic Acid | C7 | 1,800 | <50 | | 15 |
| PFOS | Perfluorooctanesulfonic Acid | C8 | 2,400,000 | 9,700 | | 22,000 |
| PFNS | Perfluorononanesulfonic Acid | C9 | 25,000 | 53 | 110 | |
| PFDS | Perfluorodecanesulfonic Acid | C10 | 40,000 | 24 | <20 | |
| PFOSA | Perfluorooctanesulfonamide | C8 | 120,000 | 92 | 130 | |
| N-EtFOSSA | N-Ethylperfluorooctanesulfonic amidoacetic Acid | C12 | 3,500,000 | 3,700 | 2,500 | |
| N-MeFOSAA | N-Methylperfluorooctanesulfonic amidoacetic Acid | C11 | 1,900 | <50 | <10 | |
| Summation of PFOA and PFOS: | | | 2,403,100 | 9,712 | | 22,035 |
| MBT-1: % PFOA+PFOS Change from Untreated | | | -64.7% | -87.9% | - | -31.9% |
| Summation of PFAS Telomere Totals): | | | 8,444,700 | 16,602 | | 24,804 |
| MBT-2: % PFAS Change from Untreated | | | -45.7% | -81.6% | - | -24.8% |

MBT – Pilot

Confidential Site Source

MBT – Treatment #2

Treated: August 28, 2020

| PFAS Telomers | Chemical Name | C Atoms | Treated: MBT-2 | | | |
|---|---|-----------|--------------------------|---------------|-----------------------|---------------|
| | | | Yost Brothers (ALS) | | FTCH (Fibertec/Trace) | |
| | | | TOTALS ng/Kg (dry-wt) | TCLP ng/L | TOTALS ng/Kg | TCLP ng/L |
| PFBA | Perfluorobutanoic Acid | C4 | <170 | <50 | NA | 12 |
| PFHpA | Perfluoroheptanoic Acid | C7 | 230 | <50 | NA | <10 |
| PFOA | Perfluorooctanoic Acid | C8 | 2,900 | 13 | NA | 35 |
| PFNA | Perfluorononanoic Acid | C9 | 93 | <10 | NA | 11 |
| PFDA | Perfluorodecanoic Acid | C10 | 10,000 | 88 | NA | <10 |
| PFUnA | Perfluoroundecanoic Acid | C11 | 1,500,000 | 3,600 | NA | <10 |
| PFDoA | Perfluorododenoic Acid | C12 | 10,000 | <50 | NA | <10 |
| PFTriA | Perfluorotridecanoic Acid | C13 | 490,000 | 150 | NA | <20 |
| PFPeS | Perfluoropentanesulfonic Acid | C5 | 38 | <10 | NA | <10 |
| PFHxS | Perfluorohexanesulfonic Acid | C6 | 450 | <50 | NA | <20 |
| PFHpS | Perfluoroheptanesulfonic Acid | C7 | 1,400 | <50 | NA | 14 |
| PFOS | Perfluorooctanesulfonic Acid | C8 | 2,200,000 | 18,000 | NA | 30,000 |
| PFNS | Perfluorononanesulfonic Acid | C9 | 22,000 | 81 | NA | 150 |
| PFDS | Perfluorodecanesulfonic Acid | C10 | 37,000 | 28 | NA | 31 |
| PFOSA | Perfluorooctanesulfonamide | C8 | 110,000 | 100 | NA | 120 |
| N-EtFOSSA | N-Ethylperfluorooctanesulfonic amidoacetic Acid | C12 | 3,000,000 | 4,200 | NA | 2,000 |
| N-MeFOSAA | N-Methylperfluorooctanesulfonic amidoacetic Acid | C11 | 2,100 | <50 | NA | <10 |
| Summation of PFOA and PFOS: | | | 2,202,900 | 18,013 | - | 30,035 |
| MBT-2: % PFOA+PFOS Change from Untreated | | | -67.6% | -77.6% | - | -7.2% |
| Summation of PFAS Telomere Totals: | | | 7,386,211 | 26,260 | - | 32,373 |
| MBT-2: % PFAS Change from Untreated | | | -52.5% | -70.9% | - | -1.8% |

MBT – Pilot (Treated TCLP)

Confidential Site Source

MBT – Treatment #1

Treated: August 28, 2020

TCLP Extraction Date = End of MBT Treatment Reactions

| | | | TREATED: MBT-1 | | | |
|-------------------------------------|---|----------------|----------------------|--------------|--------------|---------------|
| | | | 08282020 - 1100 | | | |
| | | | FTCH: Fibertec/Trace | | YB: ALS | |
| | | | 9/9/2020 | 10/21/2020 | 9/11/2020 | 10/5/2020 |
| | | | TCLP | | TCLP | |
| <u>PFAS Telomeres</u> | <u>Chemical Name</u> | <u>C Atoms</u> | <u>ng/L</u> | <u>ng/L</u> | <u>ng/L</u> | <u>ng/L</u> |
| PFBA | Perfluorobutanoic Acid | C4 | 14 | 12 | <50 | <50 |
| PFOA | Perfluorooctanoic Acid | C8 | 35 | 21 | 12 | <10 |
| PFUnA | Perfluoroundecanoic Acid | C11 | <10 | <10 | 2,800 | <50 |
| PFTriA | Perfluorotridecanoic Acid | C13 | <20 | <20 | 160 | <50 |
| PFHpS | Perfluoroheptanesulfonic Acid | C7 | 15 | <10 | <50 | <50 |
| PFOS | Perfluorooctanesulfonic Acid | C8 | 22,000 | 4,400 | 9,700 | 900 |
| PFNS | Perfluorononanesulfonic Acid | C9 | 110 | 13 | 53 | <50 |
| PFDS | Perfluorodecanesulfonic Acid | C10 | <20 | <20 | 24 | <10 |
| PFOSA | Perfluorooctanesulfonamide | C8 | 130 | 85 | 92 | 12 |
| N-EtFOSSA | N-Ethyl perfluorooctane sulfonamido acetic acid | C12 | 2,500 | 860 | 3,700 | 360 |
| N-MeFOSAA | N-Methylperfluorooctane sulfonamidoacetic acid | C11 | <10 | <10 | <50 | <50 |
| Summation of PFOA and PFOS: | | | 22,035 | 4,421 | 9,712 | 900 |
| Summation of PFAS Telomere Totals): | | | 24,804 | 5,391 | 16,602 | 1,272 |

MBT – Pilot (Treated TOTALS)

Confidential Site Source

MBT – Treatment #1

Treated: August 28, 2020

Analysis Date = End of MBT Treatment Reactions

| | | | UNTREATED: CONTROL | | | Treated: MBT-1 | | |
|------------------------------------|---|----------------|--------------------|------------------|-------------------|------------------|----------------|------------------|
| | | | 08282020-0900 | | | 08282020-1100 | | |
| | | | ALS | | Trace/Fibertec | ALS | Trace/Fibertec | ALS |
| | | | 9/11/2020 | 10/5/2020 | 9/16/2020 | 9/9/2020 | - | 10/5/2020 |
| | | | TOTALS | TOTALS | TOTALS | Totals | TOTALS | Totals |
| | | | ng/Kg (dry-wt) | ng/Kg (dry-wt) | ng/Kg (dry-wt) | ng/Kg (dry-wt) | ng/Kg (dry-wt) | ng/Kg (dry-wt) |
| <u>PFAS Telomers</u> | <u>Chemical Name</u> | <u>C Atoms</u> | | | | | | |
| PFBA | Perfluorobutanoic Acid | C4 | ND | ND | 140 | <180 | NA | <1400 |
| PFPeA | Perfluoropentanoic Acid | C5 | 170 | ND | 160 | <180 | NA | <1400 |
| PFHxA | Perfluorohexanoic Acid | C6 | 350 | ND | 340 | <180 | NA | <1400 |
| PFHpA | Perfluoroheptanoic Acid | C7 | 490 | ND | 430 | 190 | NA | <1400 |
| PFOA | Perfluorooctanoic Acid | C8 | 9,400 | 11,000 | 12,000 | 3,100 | NA | 1,800 |
| PFNA | Perfluorononanoic Acid | C9 | 270 | 670 | 1,100 | 130 | NA | <1400 |
| PFDA | Perfluorodecanoic Acid | C10 | 23,000 | ND | 1,400 | 12,000 | NA | <1400 |
| PFUnA | Perfluoroundecanoic Acid | C11 | 2,200,000 | ND | 2,800,000 | 1,600,000 | NA | <1400 |
| PFDoA | Perfluorododecanoic Acid | C12 | 12,000 | ND | ND | 10,000 | NA | <1400 |
| PFTriA | Perfluorotridecanoic Acid | C13 | 990,000 | ND | 1,200,000 | 730,000 | NA | <1400 |
| PFBS | Perfluorobutanesulfonic Acid | C4 | 79 | ND | 70 | <37 | NA | <290 |
| PFPeS | Perfluoropentanesulfonic Acid | C5 | 1,109 | ND | 130 | <37 | NA | <290 |
| PFHxS | Perfluorohexanesulfonic Acid | C6 | 1,900 | 3,000 | 2,200 | 580 | NA | <1400 |
| PFHpS | Perfluoroheptanesulfonic Acid | C7 | 7,500 | 9,700 | 8,900 | 1,800 | NA | <1400 |
| PFOS | Perfluorooctanesulfonic Acid | C8 | 6,800,000 | 8,900,000 | 10,000,000 | 2,400,000 | NA | 1,100,000 |
| PFNS | Perfluorononanesulfonic Acid | C9 | 32,000 | 45,000 | 57,000 | 25,000 | NA | 15,000 |
| PFDS | Perfluorodecanesulfonic Acid | C10 | 45,000 | 68,000 | 61,000 | 40,000 | NA | 32,000 |
| PFOSA | Perfluorooctanesulfonamide | C8 | 140,000 | 180,000 | 180,000 | 120,000 | NA | 68,000 |
| N-EtFOSSA | N-Ethyl perfluorooctane sulfonamido acetic acid | C12 | 5,300,000 | 8,300,000 | 3,300,000 | 3,500,000 | NA | 3,000,000 |
| N-MeFOSAA | N-Methylperfluorooctane sulfonamidoacetic acid | C11 | 2,200 | 4,200 | 2,900 | 1,900 | NA | 2,200 |
| Summation of PFOA and PFOS: | | | 6,809,400 | 8,911,000 | 10,012,000 | 2,403,100 | NA | 1,101,800 |
| Summation of PFAS Telomere Totals: | | | 15,565,468 | 17,521,570 | 17,627,770 | 8,444,700 | NA | 4,219,000 |

MBT – Pilot

Confidential Site Source, MI

General Summary Considerations

1. MBT process designed for 1 million ng/Kg, actual at 15-17 million ng/Kg
2. Reduced PFAS TCLP Leachability
3. Reduced total PFAS concentrations
4. Optimization via MBT reagent component blend ratio's and dose control to material
5. Prolonged process reaction duration improves performance
6. Scalable

MBT – Process Control & Cost Variables:

1. Treatment verification test methods (re: final treated material disposition/management)
2. Treatment performance criteria (leachability, strength, etc.)
3. Soil/solid material physical characteristics and chemistry (not limited to total and leachable PFAS)
4. Geo-spatial orientation of impacted material onsite
5. Vadose/water table elevations
6. Mass/volume of target material
7. Season weather patterns/ambient conditions
8. Method of MBT reagent delivery and mixing with target material
9. MBT component reagent ratios, and blended reagent dosing to target material
10. MBT process mixing and reaction durations
11. Bulk MBT reagent supply (schedule)
12. Mobilization/demobilization events
13. Treatment production rates

MBT Application Options (In-situ or Ex-situ)



