From:	Smith, Gary (Fish & Boat)
To:	Green, Pat
Cc:	Schaeffer, Brad; Baird, Josh; Smiles, Heather A
Subject:	RE: Sunoco PPP water withdrawals and discharges for hydrostatic testing
Date:	Tuesday, January 17, 2017 11:35:15 AM
Attachments:	Sunoco PPP StreamsWithHydrostaticTestingActivities - PFBC Comments 1-13-17.xlsx

Pat,

See the attached file (Column J) for our comments.

Gary

Gary A. Smith | Fisheries Biologist
PA Fish & Boat Commission
Division of Environmental Services, Natural Gas Section
236 Lake Road
Somerset, PA 15501
814-279-3080

From: Green, Pat [mailto:Pat.Green@tetratech.com]
Sent: Friday, January 13, 2017 9:06 AM
To: Smith, Gary (Fish & Boat)
Cc: Schaeffer, Brad; Baird, Josh
Subject: RE: Sunoco PPP water withdrawals and discharges for hydrostatic testing

Hi Gary, thanks for the heads up on data you need. Sorry I forgot to attach those permits! Here they are. Please note that no PAG-10 authorizations were needed for SERO. As far as your other question – here is the answer, straight from the permitting lead:

> SRBC Dockets were obtained for the 5 surface water sources that Sunoco anticipates withdrawing water quantities in excess of the SRBC threshold (>100,000 gpd average over 30 day period, or >3,000,000 gallons). Water withdrawal quantities at the other proposed water sources are expected to be below the SRBC threshold so no dockets are required. Water quantities were estimated from the length and diameter of the pipeline segments to be installed. SRBC is aware of all of the water sources that will be used and directed us to be diligent about collecting and maintaining monitoring records for all water sources because they may inspect/audit each site.

Thanks for providing us your review timeline!

Also, I will be out of town for the next two weeks, so if any additional questions arise, or you complete your review, could you please ensure you respond to Brad Schaeffer and Josh Baird? Both are cc'd on this email. They can get you any additional information you may need.

Take care,

Pat Green | Ecological Services Manager
Main: 716.849.9419 | Cell: 585.975.9782 | Fax: 716.849.9420

From: Smith, Gary (Fish & Boat) [mailto:garys@pa.gov]
Sent: Thursday, January 12, 2017 3:08 PM
To: Green, Pat <Pat.Green@tetratech.com>
Subject: RE: Sunoco PPP water withdrawals and discharges for hydrostatic testing

Pat,

You mention in your email below that PAG 10 permits were attached, but I didn't get them. Can you send them via email?

You also mentioned that 5 sites required SRBC Dockets. Why didn't the other 5 sites in the Susquehanna Basin need them?

I plan on reviewing your withdrawals/discharges within a week from now.

Thanks,

Gary

From: Green, Pat [mailto:Pat.Green@tetratech.com]
Sent: Tuesday, January 03, 2017 11:14 AM
To: Smith, Gary (Fish & Boat)
Cc: Schaeffer, Brad; Simcik, Robert; Compton, Steve
Subject: Sunoco PPP water withdrawals and discharges for hydrostatic testing

Hi Gary,

I hope you're doing well and you enjoyed the holidays. In early December Sunoco responded to DEP Technical Review Comments for PPP 105 and 102 applications. The DEP has requested that we ensure the PAFBC commission is coordinate with regarding the project's hydrostatic withdrawal/discharge activities. The project has received its PAG 10 permits and those are attached. However, it is a bit unclear if part of the PAG-10 review process includes PAFBC review, so at this time we would like to provide you the withdrawal/discharge locations and a description of the activities for you to review in terms of any concerns.

Overall, the project has a total of 16 streams where withdrawals are proposed, and 6 of those streams also have direct discharges of hydrostatic test water. I have attached a spreadsheet summarizing those streams and the activities proposed within them, as well as the PAFBC classification and applicable construction timing restriction you had previously provided. Below I have included the general procedure for typical withdrawal and discharge activities for hydrostatic

testing.

Withdrawals

All withdrawal equipment will be temporary and removable. In general, intake structures will consist of a portable pump and intake, a flexible discharge line, a flow meter, check valve, isolation valves, and storage tanks with truck connections. Possible setups include a floating intake with mobile pump, submerged intake with mobile pump, and submerged intake with submersible pump. All intake structures will have screens that are designed to avoid the entrainment and impingement of aquatic life according to regulatory agency requirements (e.g., Pennsylvania Fish and Boat Commission, United States Fish and Wildlife Service, SRBC) and the requirements included in the Canada Department of Fisheries and Oceans Freshwater Intake End-of-Pipe Fish Screen Guideline (1995). The maximum through-screen velocity will be 0.5 feet per second.

Temporary equipment will be anchored, as necessary, at the approved location to prevent movement or tampering. Flotation devices or supports will also be used to elevate the intake screen and hose when necessary to avoid sediment uptake and prevent entrainment and impingement of aquatic life. It should be noted that sites which required Susquehanna River Basin Commission (SRBC) Dockets (i.e., Susquehanna River, Swatara Creek, Conodoguinet Creek, Tuscarora Creek, and Frankstown Branch Juniata River S-M31) have site-specific details which must be followed.

Direct Discharges

All discharge equipment will be temporary and removable. In general, direct discharge structures will consist of check valves, a flow meter, compartmented portable tanks, flexible discharge lines, and matting placed on geotextile at the edge of the receiving stream. The compartmented portable tanks allow for suspended solids to settle prior to discharge. If additional removal of suspended solids is required to meet discharge limits, additional filtration equipment (i.e., sand or bag filter) can be added to the discharge end of the portable baffle tanks.

Discharge rates and water quality parameters will be in compliance with requirements set by PAG-10 discharge permits issued by the Pennsylvania Department of Environmental Protection (Approval numbers PAG103570 and PAG106192). Water quality will be collected at the end of the treatment units and sent to a fix-based laboratory for analysis. If discharge effluent limits are not met, additional treatment or offsite disposal at an approved facility will be required.

I have also attached some typical details for pumps and intakes withdrawal and discharge activity. If you could at your earliest convenience, review this information and let me know if there are any concerns of the PAFBC regarding the project's withdrawal and discharge activities. Please feel free to reach out to me with any questions – and also, I hope you have a happy and safe new year!

Pat Green | Ecological Services Manager
Tetra Tech | Natural Resource Services
Main: 716.849.9419 | Cell: 585.975.9782 | Fax: 716.849.9420
Pat.Green@tetratech.com

Tetra Tech | Complex World, Clear Solutions
301 Ellicott Street | Buffalo, NY 14203 | www.tetratech.com

Stream ID	Stream Name	County	Coordinates	PA Chapter 93 Designated Use	PAFBC Classification	PAFBC Construction Moratorium	Pipeline Activity	Hydrostatic Testing Activity	PFBC Comments for Hydrostatic Testing Activities
S7	Chartiers Creek	Washington	40.2348, -80.2125	WWF	n/a	None	HDD	Withdrawal	None
S121	Monongahela River	Allegheny	40.2300, -79.9709	WWF	n/a	None	HDD	Withdrawal and discharge	Contact Captain Tom Burrell to determine if an Aids-to-Navigation (ATON) Plan is required
S122	Youghiogheny River	Westmoreland	40.2286, -79.7727	WWF, MF	n/a	None	HDD	Withdrawal and discharge	Contact Captain Tom Burrell to determine if an Aids-to-Navigation (ATON) Plan is required
S182	Little Sewickley Creek	Westmoreland	40.2634, -79.6878	TSF	n/a	None	HDD/Temporary Bridge	Withdrawal	None
S215	Turtle Creek	Westmoreland	40.4167, -79.6069	TSF	ATW	None	HDD	Withdrawal	None (withdrawal site is 9 miles upstream of stocked trout section)
S223	Sewickley Creek	Westmoreland	40.2419, -79.7747	WWF, MF	ATW	None	Existing Bridge	Withdrawal	None (withdrawal site is 23 miles downstream of stocked trout section)
S-A17	Snitz Creek	Lebanon	40.2903, -76.4274	TSF, MF	TW, Drains to ST	3/1-6/15 and 10/1-12/31	HDD/Temporary Bridge	Withdrawal	Restriction Periods: 3/1-6/15 and 10/1-12/31
S-A22	Susquehanna River	Dauphin	40.2004, -76.7908	WWF, MF	n/a	None	HDD	Withdrawal and discharge	Contact Captain Tom Burrell to determine if an Aids-to-Navigation (ATON) Plan is required
S-B70	Swatara Creek	Dauphin	40.2189, -76.7249	WWF, MF	n/a	None	HDD	Withdrawal	Contact Captain Tom Burrell to determine if an Aids-to-Navigation (ATON) Plan is required
S-I48*	Letort Spring Run	Cumberland	40.2285, -77.1402	CWF, MF	Class A, TNR	None	HDD	Withdrawal	Restriction Period: 10/1-4/1
S-J15	Conodoguinet Creek	Cumberland	40.2416, -77.1886	WWF, MF	n/a	None	HDD	Withdrawal and discharge	Contact Captain Tom Burrell to determine if an Aids-to-Navigation (ATON) Plan is required
S-J36	Locust Creek	Cumberland	40.2442, -77.3231	WWF, MF	n/a	None	HDD	Withdrawal	None
S-K74	Tuscarora Creek	Juniata	40.3014, -77.6965	CWF, MF	ATW, STS	3/1-6/15	HDD	Withdrawal and discharge	Restriction Period: 3/1-6/15
S-L29	Aughwick Creek	Huntingdon	40.3436, -77.8522	TSF, MF	n/a	None	HDD	Withdrawal	None
S-L77	Frankstown Branch Juniata River	Blair	40.4403, -78.3295	WWF, MF	TNR	None	HDD	Withdrawal	Restriction Period: 10/1-12/31
S-M31	Frankstown Branch Juniata River	Blair	40.4344, -78.2969	WWF, MF	TNR	None	HDD	Withdrawal and discharge	Restriction Period: 10/1-12/31

*Please note Letort Spring Run has a PA Chapter 93 Existing Use Classification of HQ-CWF, M

Thomas J Burrell, Captain Waterways Conservation Officer Manager Pa Fish & Boat Commission PO Box 67000 Harrisburg, PA 17106 717-705-7838 tburrell@pa.gov

From:	Green, Pat
To:	Smith, Gary (Fish & Boat)
Cc:	Schaeffer, Brad; Simcik, Robert; Compton, Steve
Subject:	Sunoco PPP water withdrawals and discharges for hydrostatic testing
Date:	Tuesday, January 03, 2017 11:14:02 AM
Attachments:	Detail 1 typical submersible pump detail.pdf Detail 2 typical double floating intake with mobile pump.pdf Detail 3 typical submerged intake with mobile pump.pdf Detail 4 typical single floating intake with mobile pump.pdf Discharge BMPs.pdf StreamsWithHydrostaticTestingActivities.xlsx

---

Hi Gary,

I hope you're doing well and you enjoyed the holidays. In early December Sunoco responded to DEP Technical Review Comments for PPP 105 and 102 applications. The DEP has requested that we ensure the PAFBC commission is coordinate with regarding the project's hydrostatic withdrawal/discharge activities. The project has received its PAG 10 permits and those are attached. However, it is a bit unclear if part of the PAG-10 review process includes PAFBC review, so at this time we would like to provide you the withdrawal/discharge locations and a description of the activities for you to review in terms of any concerns.

Overall, the project has a total of 16 streams where withdrawals are proposed, and 6 of those streams also have direct discharges of hydrostatic test water. I have attached a spreadsheet summarizing those streams and the activities proposed within them, as well as the PAFBC classification and applicable construction timing restriction you had previously provided. Below I have included the general procedure for typical withdrawal and discharge activities for hydrostatic testing.

Withdrawals

All withdrawal equipment will be temporary and removable. In general, intake structures will consist of a portable pump and intake, a flexible discharge line, a flow meter, check valve, isolation valves, and storage tanks with truck connections. Possible setups include a floating intake with mobile pump, submerged intake with mobile pump, and submerged intake with submersible pump. All intake structures will have screens that are designed to avoid the entrainment and impingement of aquatic life according to regulatory agency requirements (e.g., Pennsylvania Fish and Boat Commission, United States Fish and Wildlife Service, SRBC) and the requirements included in the Canada Department of Fisheries and Oceans Freshwater Intake End-of-Pipe Fish Screen Guideline (1995). The maximum through-screen velocity will be 0.5 feet per second.

Temporary equipment will be anchored, as necessary, at the approved location to prevent movement or tampering. Flotation devices or supports will also be used to elevate the intake screen and hose when necessary to avoid sediment uptake and prevent entrainment and impingement of aquatic life. It should be noted that sites which required Susquehanna River Basin Commission (SRBC) Dockets (i.e., Susquehanna River, Swatara Creek, Conodoguinet Creek, Tuscarora Creek, and Frankstown Branch Juniata River S-M31) have site-specific details which must be followed.

Direct Discharges

All discharge equipment will be temporary and removable. In general, direct discharge structures will consist of check valves, a flow meter, compartmented portable tanks, flexible discharge lines, and matting placed on geotextile at the edge of the receiving stream. The compartmented portable tanks allow for suspended solids to settle prior to discharge. If additional removal of suspended solids is required to meet discharge limits, additional filtration equipment (i.e., sand or bag filter) can be added to the discharge end of the portable baffle tanks.

Discharge rates and water quality parameters will be in compliance with requirements set by PAG-10 discharge permits issued by the Pennsylvania Department of Environmental Protection (Approval numbers PAG103570 and PAG106192). Water quality will be collected at the end of the treatment units and sent to a fix-based laboratory for analysis. If discharge effluent limits are not met, additional treatment or offsite disposal at an approved facility will be required.

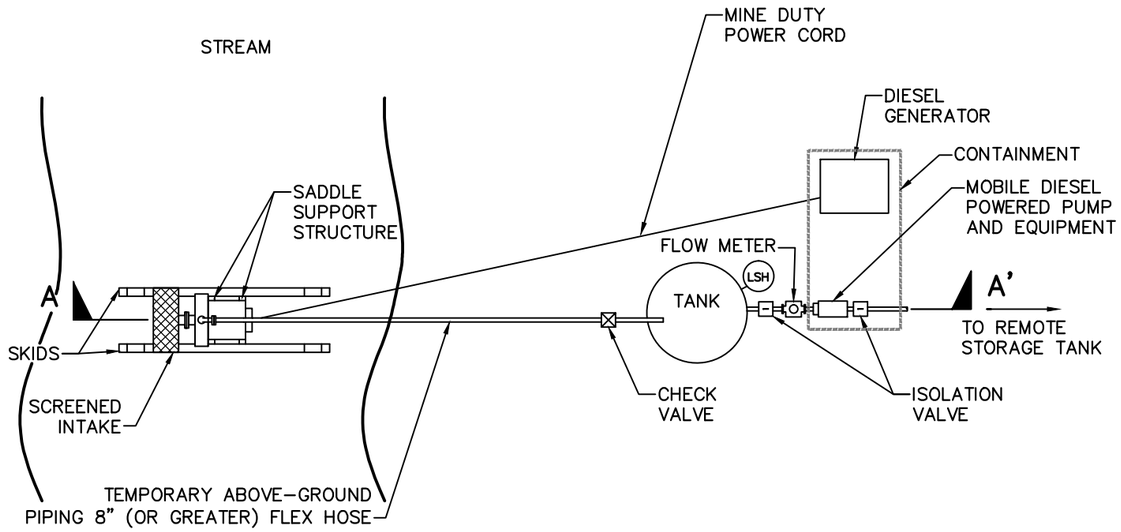
I have also attached some typical details for pumps and intakes withdrawal and discharge activity. If you could at your earliest convenience, review this information and let me know if there are any concerns of the PAFBC regarding the project's withdrawal and discharge activities. Please feel free to reach out to me with any questions – and also, I hope you have a happy and safe new year!

Pat Green | Ecological Services Manager
Tetra Tech | Natural Resource Services
Main: 716.849.9419 | Cell: 585.975.9782 | Fax: 716.849.9420
Pat.Green@tetratech.com

Tetra Tech | Complex World, Clear Solutions
301 Ellicott Street | Buffalo, NY 14203 | www.tetratech.com

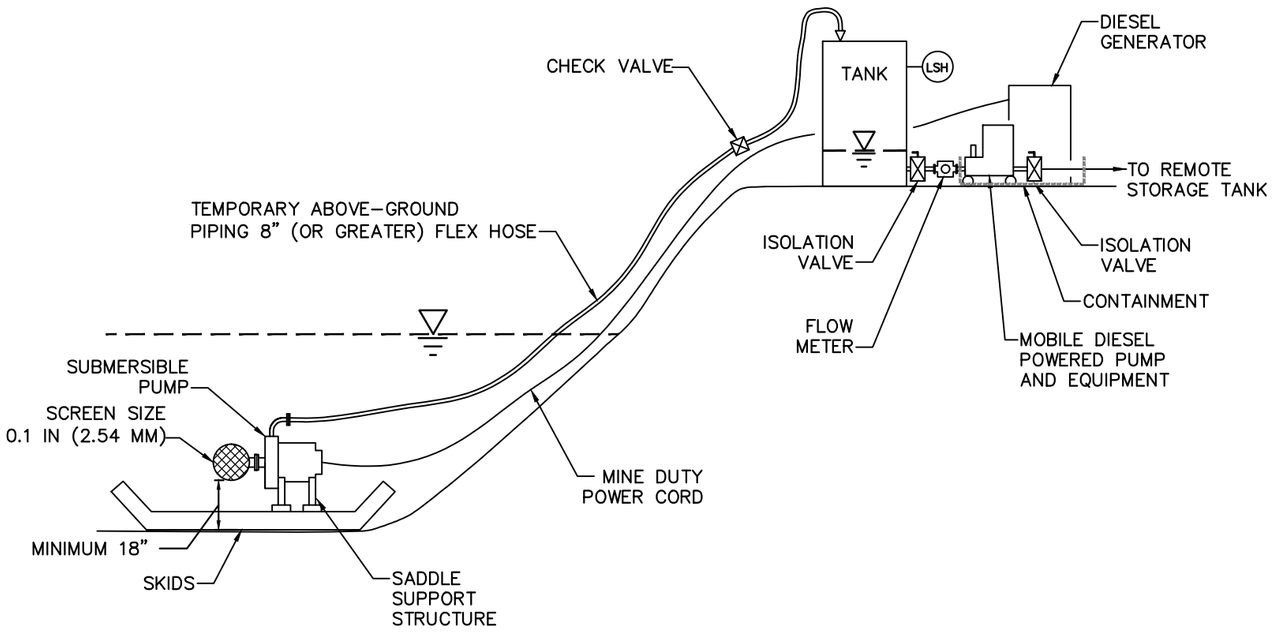
Stream ID	Stream Name	County	Coordinates	PA Chapter 93 Designated Use	PAFBC Classification	PAFBC Construction Moratorium	Pipeline Activity	Hydrostatic Testing Activity
S7	Chartiers Creek	Washington	40.2348, -80.2125	WWF	n/a	None	HDD	Withdrawal
S121	Monongahela River	Allegheny	40.2300, -79.9709	WWF	n/a	None	HDD	Withdrawal and discharge
S122	Youghiogheny River	Westmoreland	40.2286, -79.7727	WWF, MF	n/a	None	HDD	Withdrawal and discharge
S182	Little Sewickley Creek	Westmoreland	40.2634, -79.6878	TSF	n/a	None	HDD/Temporary Bridge	Withdrawal
S215	Turtle Creek	Westmoreland	40.4167, -79.6069	TSF	ATW	None	HDD	Withdrawal
S223	Sewickley Creek	Westmoreland	40.2419, -79.7747	WWF, MF	ATW	None	Existing Bridge	Withdrawal
S-A17	Snitz Creek	Lebanon	40.2903, -76.4274	TSF, MF	ATW, Drains to STS	3/1-6/15 and 10/1-12/31	HDD/Temporary Bridge	Withdrawal
S-A22	Susquehanna River	Dauphin	40.2004, -76.7908	WWF, MF	n/a	None	HDD	Withdrawal and discharge
S-B70	Swatara Creek	Dauphin	40.2189, -76.7249	WWF, MF	n/a	None	HDD	Withdrawal
S-I48*	Letort Spring Run	Cumberland	40.2285, -77.1402	CWF, MF	Class A, TNR	None	HDD	Withdrawal
S-J15	Conodoguinet Creek	Cumberland	40.2416, -77.1886	WWF, MF	n/a	None	HDD	Withdrawal and discharge
S-J36	Locust Creek	Cumberland	40.2442, -77.3231	WWF, MF	n/a	None	HDD	Withdrawal
S-K74	Tuscarora Creek	Juniata	40.3014, -77.6965	CWF, MF	ATW, STS	3/1-6/15	HDD	Withdrawal and discharge
S-L29	Aughwick Creek	Huntingdon	40.3436, -77.8522	TSF, MF	n/a	None	HDD	Withdrawal
S-L77	Frankstown Branch Juniata River	Blair	40.4403, -78.3295	WWF, MF	TNR	None	HDD	Withdrawal
S-M31	Frankstown Branch Juniata River	Blair	40.4344, -78.2969	WWF, MF	TNR	None	HDD	Withdrawal and discharge

*Please note Letort Spring Run has a PA Chapter 93 Existing Use Classification of HQ-CWF, MF.



SCHEMATIC PLAN VIEW

NOT TO SCALE



INTAKE ARRANGEMENT SECTION A-A'

NOT TO SCALE

NOTES:

1. PUMP PAD WILL MATCH EXISTING GRADE.
2. SURFACE WATER SOURCE TO BE USED FOR TEMPORARY WATER WITHDRAWALS. ALL TEMPORARY EQUIPMENT WILL BE REMOVED FROM THE FLOODWAY WHEN NOT IN USE. NO DREDGING OR FILLING ACTIVITIES CAN BE COMPLETED WITHIN THE 100-YEAR FLOODWAY WITHOUT ADDITIONAL PERMITS.
3. LSH = LEVEL SWITCH HIGH

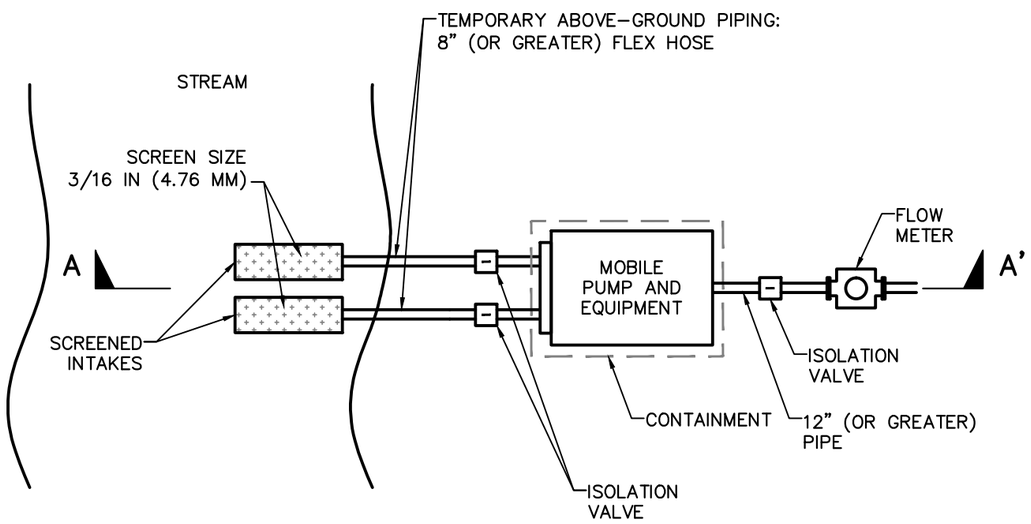
TETRA TECH
WWW.TETRATECH.COM
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

SUNOCO PIPELINE L.P.
SINKING SPRING, PENNSYLVANIA

TYPICAL HYDROSTATIC TEST SUBMERGED WATER INTAKE WITH SUBMERGED PUMP

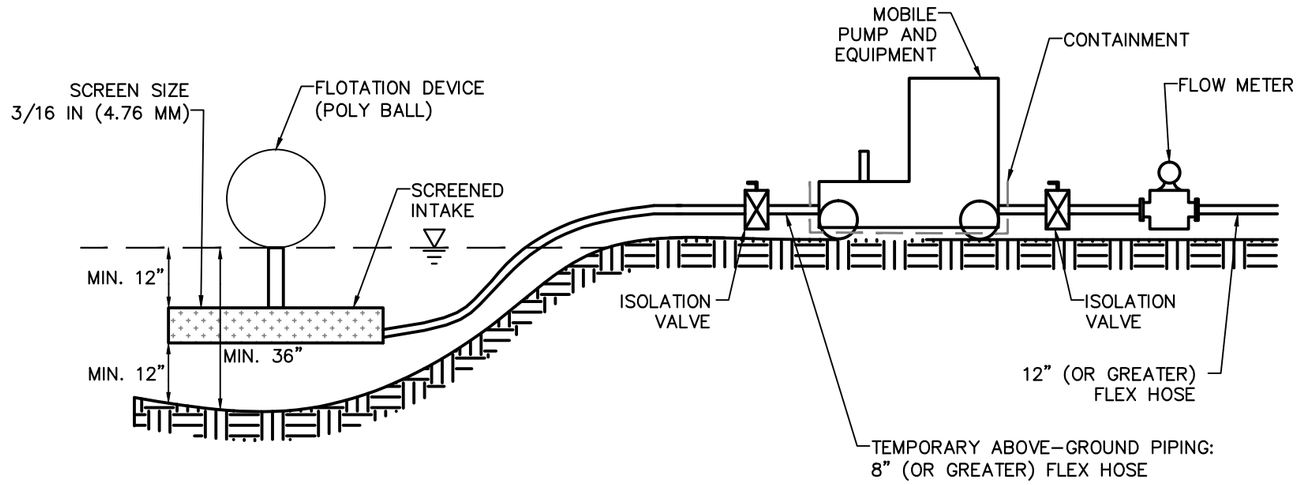
DATE:	3/17/16
PROJECT NO.:	112IC05958
DESIGNED BY:	
DRAWN BY:	CK
CHECKED BY:	
SHEET:	1 OF 1

DETAIL 1



SCHEMATIC
PLAN VIEW

NOT TO SCALE



INTAKE ARRANGEMENT
SECTION A–A'

NOT TO SCALE

NOTES:

1. PUMP PAD WILL MATCH EXISTING GRADE.
2. SURFACE WATER SOURCE TO BE USED FOR TEMPORARY WATER WITHDRAWALS. ALL TEMPORARY EQUIPMENT WILL BE REMOVED FROM THE FLOODWAY WHEN NOT IN USE. NO DREDGING OR FILLING ACTIVITIES CAN BE COMPLETED WITHIN THE 100–YEAR FLOODWAY WITHOUT ADDITIONAL PERMITS.

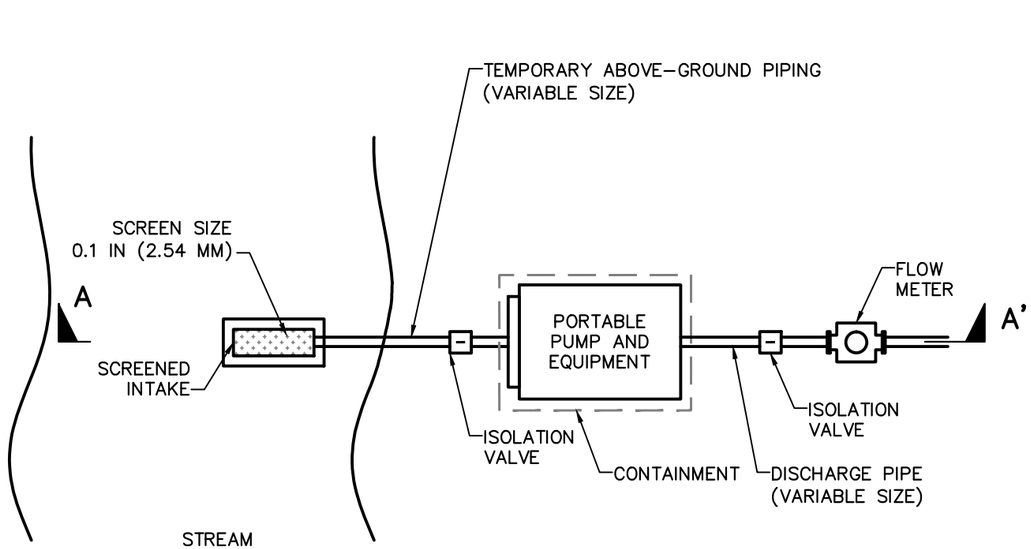
TETRA TECH
WWW.TETRATECH.COM
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921–7090 | F: (412) 921–4040

SUNOCO PIPELINE L.P.
SINKING SPRING, PENNSYLVANIA

TYPICAL HYDROSTATIC TEST
FLOATING INTAKE WITH MOBILE PUMP

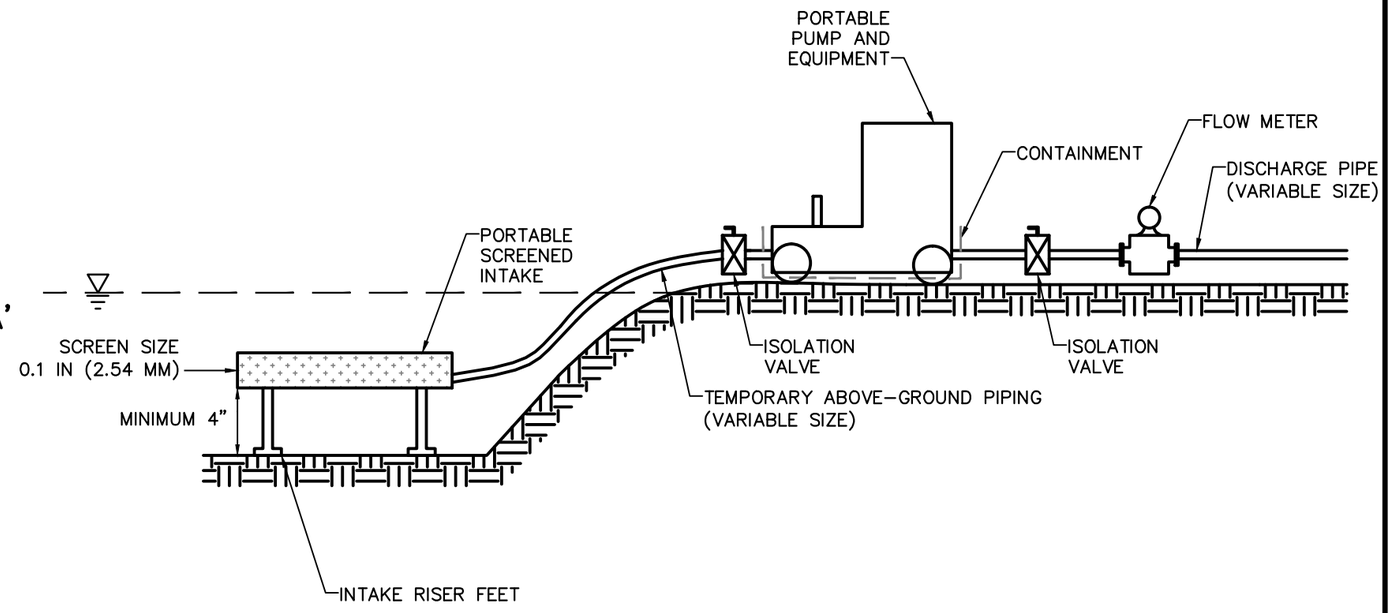
DATE:	3/17/16
PROJECT NO.:	112IC05958
DESIGNED BY:	
DRAWN BY:	CK
CHECKED BY:	
SHEET:	1 OF 1

DETAIL 2



SCHEMATIC
PLAN VIEW

NOT TO SCALE



INTAKE ARRANGEMENT
SECTION A-A'

NOT TO SCALE

NOTES:

1. PUMP PAD WILL MATCH EXISTING GRADE.
2. SURFACE WATER SOURCE TO BE USED FOR TEMPORARY WATER WITHDRAWALS. ALL TEMPORARY EQUIPMENT WILL BE REMOVED FROM THE FLOODWAY WHEN NOT IN USE. NO DREDGING OR FILLING ACTIVITIES CAN BE COMPLETED WITHIN THE 100-YEAR FLOODWAY WITHOUT ADDITIONAL PERMITS.

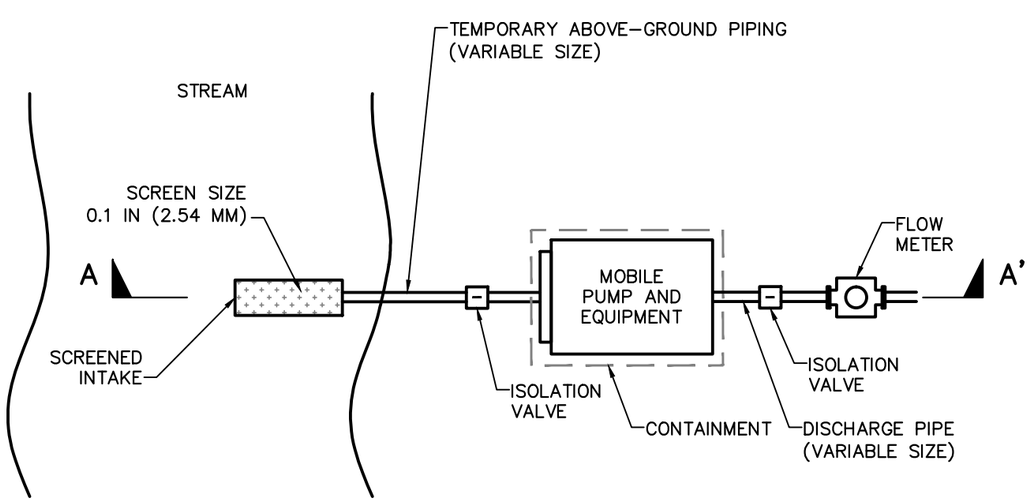
TETRA TECH
WWW.TETRATECH.COM
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

SUNOCO PIPELINE L.P.
SINKING SPRING, PENNSYLVANIA

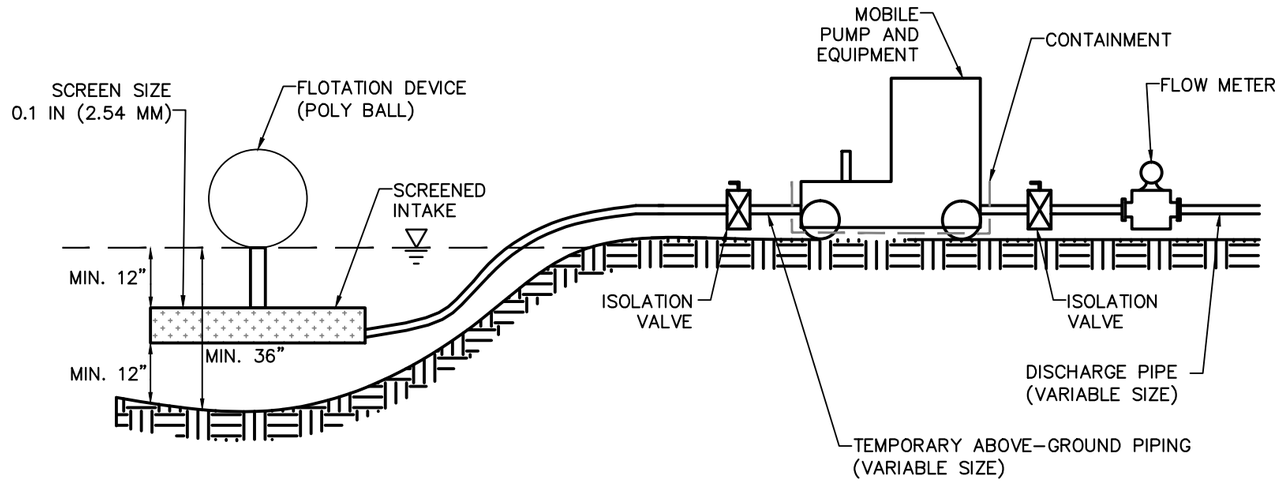
TYPICAL HYDROSTATIC TEST
SUBMERGED INTAKE WITH MOBILE PUMP

DATE:	8/24/16
PROJECT NO.:	112IC05958
DESIGNED BY:	
DRAWN BY:	CK
CHECKED BY:	
SHEET:	1 OF 1

DETAIL 3



SCHEMATIC
PLAN VIEW
NOT TO SCALE



INTAKE ARRANGEMENT
SECTION A-A'
NOT TO SCALE

NOTES:

1. PUMP PAD WILL MATCH EXISTING GRADE.
2. SURFACE WATER SOURCE TO BE USED FOR TEMPORARY WATER WITHDRAWALS. ALL TEMPORARY EQUIPMENT WILL BE REMOVED FROM THE FLOODWAY WHEN NOT IN USE. NO DREDGING OR FILLING ACTIVITIES CAN BE COMPLETED WITHIN THE 100-YEAR FLOODWAY WITHOUT ADDITIONAL PERMITS.

TETRA TECH
WWW.TETRATECH.COM
661 ANDERSEN DRIVE - FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

SUNOCO PIPELINE L.P.
SINKING SPRING, PENNSYLVANIA

TYPICAL HYDROSTATIC TEST
FLOATING INTAKE WITH MOBILE PUMP

DATE:	8/24/16
PROJECT NO.:	112IC05958
DESIGNED BY:	
DRAWN BY:	CK
CHECKED BY:	
SHEET: 1 OF 1	

DETAIL 4

ATTACHMENT 1.9

BEST MANAGEMENT PRACTICES (BMPS)

Sampling and Analysis Program for Hydrostatic Test Waters for PPP in PA

Intended User: Sunoco or Sunoco Representative Sampler

Scope

This document identifies the methods to be used to perform sampling and analysis of waters used to hydrostatically test pipeline segments installed by horizontal directional drilling (HDD) or the entire pipeline of PPP in Pennsylvania. These waters must be tested and shown to be in compliance with the requirements of the Pennsylvania Department of Environmental Protection's General Permit for Discharges from Hydrostatic Testing of Tanks and Pipelines before being discharged.

Purpose

The sampling and analysis program is necessary to provide the required information to show compliance with the effluent limitations and monitoring requirements required under the Federal Water Pollution Control Act (Clean Water Act) and Pennsylvania Clean Streams Law (35 P.S. Section 691.1 et seq.). Proper sampling procedures (collection, preservation, storage, and chain-of-custody) must be followed so that the data is accurate and valid.

Analytical Program

Table 1 on Page 7 summarizes the sampling and monitoring requirements in the Pennsylvania Department of Environmental Protection's General Permit for Discharges from Hydrostatic Testing of New Tanks and Pipelines. These requirements apply to this project.

The testing program will be completed in three steps. Water to be used for hydrostatic testing will be tested at the source to provide baseline analytical results for the water source. Hydrostatic test waters will be tested in the field after testing but before discharge to allow for rapid assessment of the quality of the water. This will allow the waters to be discharged at the completion of the hydrostatic test without significant delays. Samples will also be collected and sent to a fixed-base laboratory to confirm the results of the field tests. The analytical results from the fixed-based laboratory will provide final confirmation that the water quality was in compliance with the applicable standards.

Procedures

The following procedures will be followed for this project:

- Samples should be taken in a timely manner to ensure that analytical data is available within the required reporting period specified in the permit.

- Samples should be collected at each water source that will be used to complete the HDD. These samples should be sent to the fixed-base laboratory for analysis.

- Samples of the test water should be taken from the end of the treatment units, unless a location is otherwise noted in the site-specific permit.

- Samples collected should be representative of the test water being discharged.

- For each sample taken, EPA- and laboratory-specified sample collection devices, containers, and preservation techniques must be used.

- All samples should be labeled with the date and time each sample was collected, the location of the sample, the preservative used, the test parameters, and the name/initials of the sample collector. Each sample location should be assigned a unique ID number and included on the sample label and chain-of-custody.

- Complete chain-of-custody form, including signature of the sampler, and ship the samples to the project laboratory for analysis.

- Samples must be analyzed within the maximum holding time for the parameter being analyzed. Samples must be provided to the laboratory in sufficient time to allow analysis within the holding times.

Sample Collection Procedures

- Refer to Table 2 – Field Analysis of Hydrostatic Test Waters on Page 8 for the appropriate sample container and procedures to be used for the field tests. Refer to Table 3 - Laboratory Analysis of the Hydrostatic Test Waters on Page 9 for the appropriate sample container and procedures to be used for the samples to be sent to the fixed-base laboratory.

- Ensure all appropriate meters, field test kits, sample bottles, filters, sample collectors, and coolers/storage containers are available and ready prior to discharge.

- Follow all manufacturers' instructions with field meters. A multi-parameter water quality meter is recommended for field measurement of dissolved oxygen and pH. A field meter or test kit will be used for measurement of TSS, oil and grease, iron, and total residual chlorine.

- All field meters should be calibrated as specified by the manufacturer. If a calibration frequency specification is not given, calibrate the meter prior to each use.

    - A log should be kept indicating the date/time each calibration was performed.

    - Care should be taken to ensure all reagents or buffers needed for calibrations are within their expiration date for use.

- Sampler should wear sterile powder free nitrile gloves (or equivalent) when collecting samples and performing field analysis.

- Sample should be collected within the center of the discharge flow, where possible. If samples are taken at the end of a filter bag, sediment trap, or other device, each sample should be taken from the same point at the end of these structures.

- Each sample container should be filled to the top of the container, leaving no airspace. Care should be taken not to overfill the container. Ensure the sample container being used is large enough for the amount of sample needed and that the appropriate container is being used.

- If a sample cannot be collected using the appropriate sample container, a stainless steel dipper can be used to collect the sample and transfer to the sample container, where appropriate. Care must be taken to ensure no contamination of the sample occurs between the collection point and the container.

- Composite samples, where required, are obtained by collecting individual samples over a period of time and combining them into one container. Add each individual sample to the composite container as it is collected. Preservatives should be added to the composite bottle initially, if not pre-added, so all portions of the sample are composite are preserved as soon as collected. See Table 1 for those analyses requiring composite samples.

- Dissolved Oxygen and pH will be measured in the field using a multi-parameter water quality meter. The water for these measurements should be collected into a clean 5-gallon bucket (clean plastic or stainless steel) and water quality probe immediately inserted directly into the bucket, measurements must be recorded into a field log book along with the date time and location of the measurements. TSS, oil and grease, iron, and total residual chlorine will be collected per test kit manufacturer's instructions.

- Laboratory samples should be preserved according to the appropriate guideline for each sample parameter (Refer to Table 3). If not pre-added in the sample containers, preservatives should be added immediately after sample collection. Caution should be taken when adding preservatives, as they are typically harmful if contact is made with skin, eyes, lungs, etc. If preservatives are pre-added, ***DO NOT*** pre-rinse sample container. Care should be taken not to overfill container. See the following parameter list for the appropriate preservation method, if preservatives are not pre-added.

- Laboratory samples should be stored according to the appropriate guidelines for each sample parameter (Refer to Table 3). Sample coolers/storage containers should be kept clean to ensure no contamination occurs during storage and delivery. If sample must be cooled, a cooler full of ice will sufficiently cool the sample. See Table 3 for the appropriate preservation and storage method.

Procedures for Sample Handling, Documentation, and Analysis

Field records (logbook and/or log sheets) should be kept during sampling to document the procedures used. Each page should be completed with an indelible-ink pen and be legible. Any mistakes must be struck out with a single line through the mistake and the sampler's initials and date.

The objectives of sample handling and shipping procedures are to maintain the physical form and chemical composition of the sample and to prevent potential cross-contamination from other sources or changes in analyte concentration. To meet these objectives, there must be a measure of control over all sample-handling procedures beginning with sample container selection procedures and ending with laboratory analysis. These procedures should be followed by the sampling team collecting and shipping samples as well as laboratories.

Sample Bottle Storage and Transport

During every step of the process, care must be taken to avoid cross-contamination. Sample bottles and coolers must be stored and transported in contaminant-free environments at all times. Sample bottles should never be stored near solvents, gasoline, or other equipment that may be a potential source of contamination. Sample bottles should be secured in locked vehicles, locked storage rooms, or in the presence of authorized personnel.

Sample Packaging Custody Control

The packaging for sample bottles shipped by the laboratory should be custody-sealed (tamper-evident adhesive labels signed and dated by the laboratory). Upon receipt, sampling personnel should record in the field notes whether the custody seal(s) were intact upon arrival. This assures that the sample containers were not tampered with between the time of their preparation and their arrival. If the custody seal is broken, it is recommended that the sample containers not be used for sample collection. After sample collection, the samples should be properly packaged in a cooler and the cooler should be custody-sealed for return shipment to the laboratory. Upon arrival at the laboratory, the person receiving the sample(s) should note the condition of the custody seal(s) on the cooler receipt documentation. If the custody seal is broken, the operator should be contacted to determine the appropriate course of action.

Chain-of-Custody (COC) Form

The COC is a legal document and must be filled out completely by the sample team and accompany each sample shipment container. The COC should be properly sealed in a zipper-lock plastic bag and placed on top of the samples in the cooler or the bag may be taped inside the cooler lid. The cooler should be secured with shipping tape which should cover the custody seal.

The COC should include, but not be limited to, the following information:

- Site name (e.g. HDD bore or pipe segment)
- Unique sample identifier
- Sampler's name
- Date and time of collection (recorded in 24 hour clock time)
- Type of sample (grab or composite)
- Sample matrix (hydrostatic test water, potable water, or surface water)
- Sample description (as appropriate)
- Number of containers
- Preservative information
- Parameters requested (i.e., tests, methods)
- Blocks for noting date, time and signatures for sample receipt and transfer
- Other information as required by the operator or the database management system being used

Sample Labeling

It is recommended that sample labels be completed using indelible ink prior to sample collection at the water source. Sample container labels should include the following information: unique sample identifier, date and time the sample is collected, preservative, test parameter, and sampler initials. Use of tape on sample containers is not recommended; however, it may be necessary to secure labels with clear tape if the label adhesive will not adhere to sample containers when wet.

Sample Handling

After the samples have been collected they should be immediately placed on wet ice in an insulated shipping container. The samples should be kept at <6°C during storage and shipment to the analytical laboratory. Each cooler should be packed and sealed in a manner to help minimize potential damage to sample containers, to help maintain the required temperature, and to help prevent tampering.

Due to ambient conditions and transportation time, samples may need to be pre-cooled before being packed into the sample shipment container.

Reporting

All analytical results, even those below the Practical Quantitation Limit (PQL) shall be reported by the analytical laboratory. Analytical results are to be reported as follows:

- For results above the PQL, report the analytical result for the parameter of concern.
- For results above the Method Detection Limit (MDL), but below the PQL, report the analytical result, even though it is below the PQL.
- For results below the MDL, report the analytical result as "below detection" using the reporting code "AA".

Safety

Sample collection and preservation will be conducted in a safe manner following appropriate health and safety protocols. Samplers should wear appropriate personal protective equipment when sampling. Situations that may lead to accidents should be avoided.

Table 1 – PADEP Hydrostatic Water Analytical and Monitoring Program for New Tanks and Pipelines

Parameter	Effluent Requirement			Monitoring Requirements	
	Minimum	Average Monthly	Instant. Maximum	Minimum Measurement Frequency (1, 2)	Sample Type
Flow Rate (GPM)	-	Report	-	1/discharge	Measured
Duration of Discharge (hours)	-	Report	-	1/discharge	Measured
Total Volume Discharged (gallons)	-	Report Total Monthly	-	1/month	Calculated
Dissolved Oxygen (mg/L)	5.0	-	-	2/discharge	Grab
pH (S.U.)	6.0	-	9.0	2/discharge	Grab
Total Residual Chlorine (TRC) (mg/L)	-	Report	0.05	2/discharge	Grab
Total Suspended Solids (TSS) (mg/L)	-	30	60	1/discharge	Grab
Oil and Grease (mg/L)	-	15	30	1/discharge	Grab
Dissolved Iron (mg/L)	-	-	7.0	1/discharge	Grab

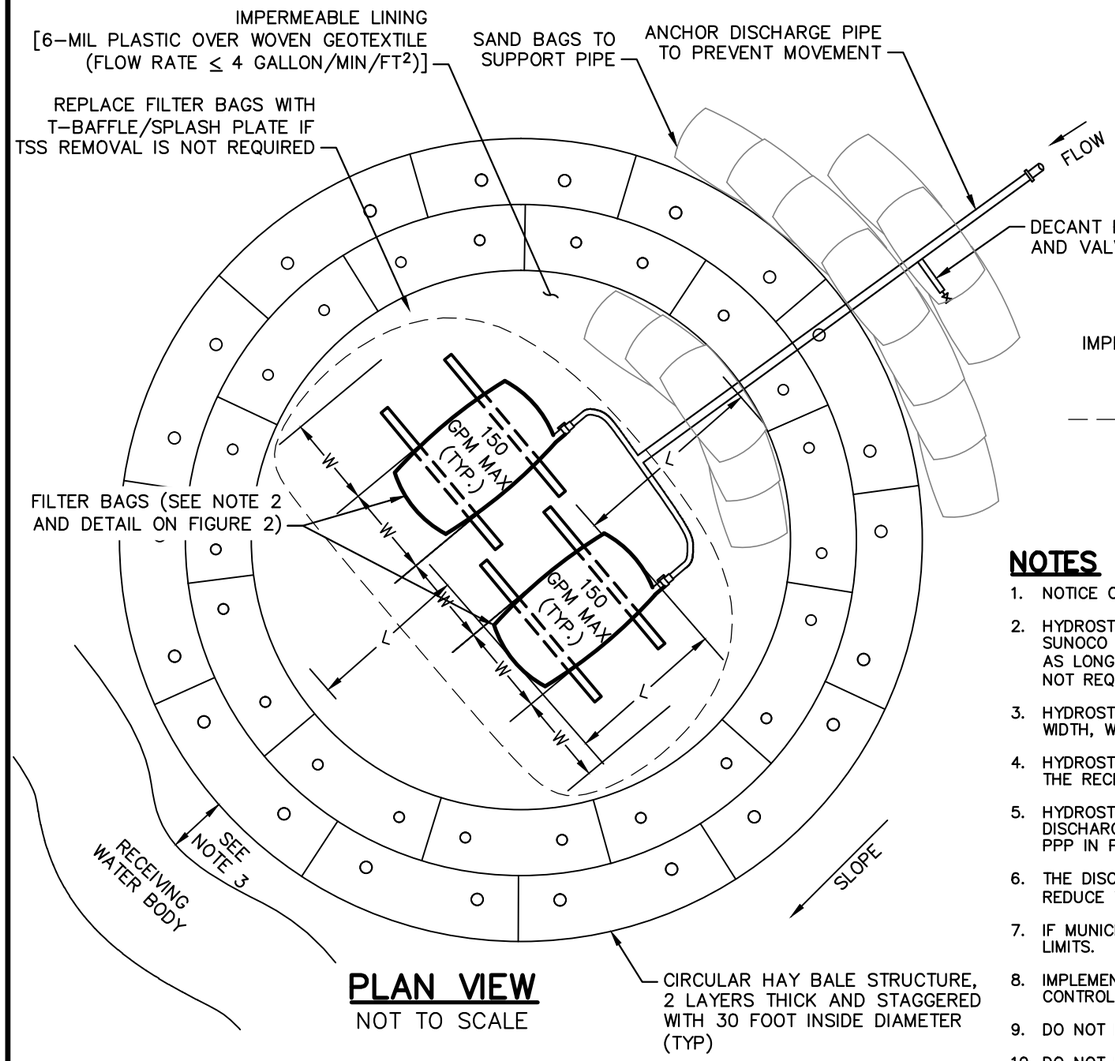
(1) For measurement frequencies of 1/discharge, collect samples within the first 30 minutes of commencing a discharge.
(2) For measurement frequencies of 2/discharge, collect one sample at the start of a discharge and one sample at the end of the discharge.

Table 2 – Field Analysis of Hydrostatic Test Waters
Bottleware, Preservation, and Holding Times

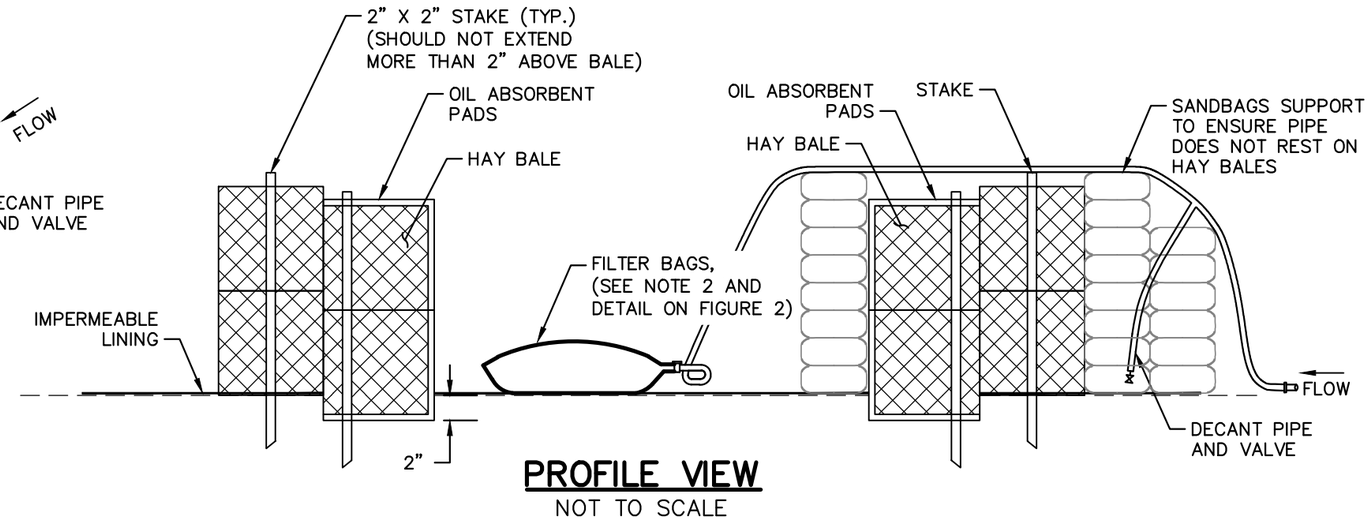
Parameter	Analytical Method	Bottleware	Preservation	Holding time
pH (S.U.)	In field with multi-parameter water quality meter	5 Gallon HDPE or Stainless steel bucket	None	Analyze immediately
Dissolved Oxygen (mg/L)	In field with multi-parameter water quality meter	5 Gallon HDPE or Stainless steel bucket	None	Analyze immediately
Total Suspended Solids (mg/L)	HACH portable meter Product #:LXV322.99.00002	5 Gallon HDPE or Stainless steel bucket	None	Analyze immediately
Oil and Grease (mg/L)	Sitelab®Model No. TD-500D	5 Gallon HDPE or Stainless steel bucket	None	Analyze immediately
Iron, Dissolved (ug/L)	Filter with 0.45 micron filter, HACH Iron Color Disc Test Kit, Model IR-18A	5 Gallon HDPE or Stainless steel bucket	None	Analyze immediately
Chlorine, Total Residual (mg/L)	HACH Pocket Colorimeter™ II or CN-70 kit or CN-70T kit	5 Gallon HDPE or Stainless steel bucket	None	Analyze immediately

Table 3 – Laboratory Analysis of the Hydrostatic Test Waters
Bottleware, Preservation, and Holding Times

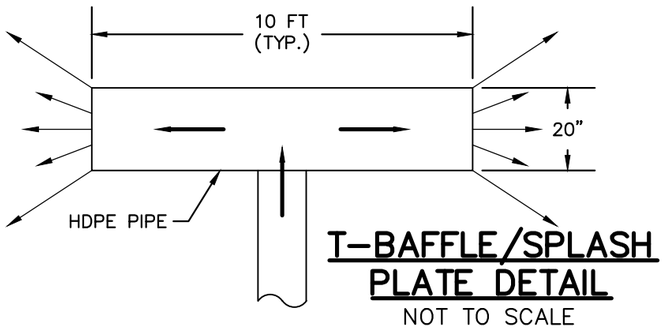
Parameter	Analytical Method	Bottleware	Preservation	Holding time
pH (S.U.)	EPA 150.2	250 mL HDPE	None	Analyze immediately
Dissolved Oxygen (mg/L)	EPA 360.2	300 mL BOD	The sample should be stored at the temperature of the collection water, or sealed and kept at a temperature of 10° to 20°C in the dark. Add 0.7 mL of conc. H_2SO_4 and 1 mL sodium azide solution to sample in the BOD bottle.	Analyze immediately
Total Suspended Solids (mg/L)	EPA 160.2 or SM2540D	250 mL HDPE	None	7 days to analysis
Oil and Grease (mg/L)	EPA 1664	1 L glass	Add hydrochloric acid to a pH<2; Cool to 0-6° C	28 days to analysis
Iron, Dissolved (ug/L)	EPA 200.7	250 mL HDPE	Filter with 0.45 micron filter, Add Nitric acid to a pH<2	180 days to analysis
Chlorine, Total Residual (mg/L)	SM 4500_Cl_G	250 mL HDPE	None	Analyze immediately



PLAN VIEW
NOT TO SCALE



PROFILE VIEW
NOT TO SCALE



T-BAFFLE/SPLASH PLATE DETAIL
NOT TO SCALE

NOTES

1. NOTICE OF INTENT MUST BE SUBMITTED AND NOTIFICATION OF PERMIT COVERAGE RECEIVED PRIOR TO DISCHARGING HYDROSTATIC TEST WATER.
2. HYDROSTATIC TEST WATER DISCHARGE STRUCTURE WILL BE LOCATED WITHIN THE PROJECT RIGHT-OF-WAY OR OTHER ESTABLISHED RIGHT-OF-WAY APPROVED BY SUNOCO AND LANDOWNER. INCREASE SIZE OF DISCHARGE STRUCTURE AND NUMBER OF FILTER BAGS TO MATCH REQUIRED DISCHARGE RATE AND TSS REMOVAL AS LONG AS REQUIRED LAND IS AVAILABLE. ADD ADDITIONAL SMALLER DISCHARGE STRUCTURES IF SPACE IS LIMITED. ELIMINATE FILTER BAG(S) IF TSS REMOVAL NOT REQUIRED AND REPLACE WITH T-BAFFLE/ SPLASH PLATE.
3. HYDROSTATIC WATER DISCHARGE STRUCTURE WILL BE LOCATED AT LEAST 100 FEET FROM THE EDGE OF A DELINEATED WETLAND, AND 50 FEET OR THE CHANNEL WIDTH, WHICHEVER IS GREATER, FROM THE TOP OF BANK OF A RECEIVING STREAM.
4. HYDROSTATIC WATER DISCHARGE STRUCTURE WILL BE LOCATED SUCH THAT IT DRAINS TO A WELL-VEGETATED AREA WITH SLOPES BETWEEN 1% AND 5% TOWARD THE RECEIVING WATERBODY.
5. HYDROSTATIC TEST WATER MUST BE SAMPLED AND ANALYZED TO CONFIRM COMPLIANCE WITH PARAMETERS IDENTIFIED IN PADEP PAG-10 GENERAL PERMIT FOR DISCHARGE FROM HYDROSTATIC TESTING OF TANKS AND PIPELINES AND THE APPROVED SAMPLING AND ANALYSIS PROGRAM FOR HYDROSTATIC TEST WATERS FOR PPP IN PENNSYLVANIA.
6. THE DISCHARGE RATE TO THE STRUCTURE SHOULD BE LIMITED TO THE LOWEST POSSIBLE RATE TO MINIMIZE ANY POTENTIAL IMPACT ON AQUATIC LIFE AND TO REDUCE THE POTENTIAL FOR EROSION (E.G., 150 GPM).
7. IF MUNICIPAL WATER IS USED FOR TESTING, HOLD THE WATER IN THE PIPE FOR AT LEAST 24 HOURS PRIOR TO DISCHARGE TO MEET TOTAL RESIDUAL CHLORINE LIMITS.
8. IMPLEMENT ADDITIONAL EROSION AND SEDIMENT CONTROLS AS REQUIRED IN PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION EROSION AND SEDIMENT CONTROL PROGRAM MANUAL, TECHNICAL GUIDANCE NUMBER 363-2134-008, MARCH 2012.
9. DO NOT DISCHARGE HYDROSTATIC TEST WATER TO EV OR HQ WATERS.
10. DO NOT DISCHARGE HYDROSTATIC TEST WATER TO TROUT STOCKED STREAMS FROM MARCH 1 TO JUNE 15. THE LISTING OF TROUT STOCKED STREAMS CAN BE FOUND ON THE PENNSYLVANIA FISH AND BOAT COMMISSION'S WEBSITE: WWW.FISH.STATE.PA.US.
11. A PREPAREDNESS, PREVENTION, AND CONTINGENCY (PPC) PLAN MUST BE DEVELOPED IN ACCORDANCE WITH PA DEP'S "GUIDELINES FOR THE DEVELOPMENT AND IMPLEMENTATION OF ENVIRONMENTAL EMERGENCY RESPONSE PLANS" (DEP ID 400-2200-001) AND ITS NPDES-SPECIFIC ADDENDUM. THE PPC PLAN MUST BE MAINTAINED ON-SITE AND BE MADE AVAILABLE UPON REQUEST.

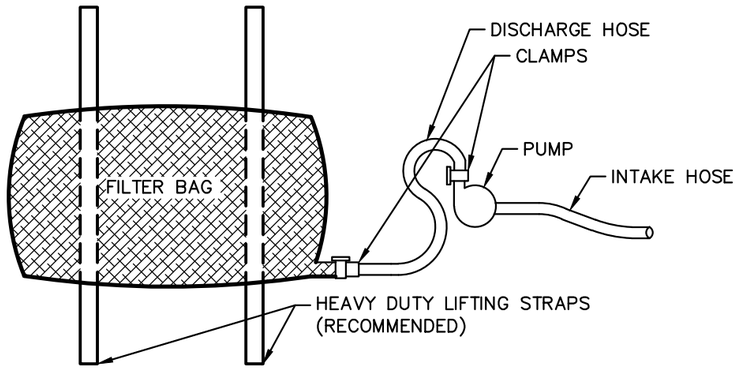
TETRA TECH
WWW.TETRATECH.COM
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

SUNOCO PIPELINE L.P.
SINKING SPRING, PENNSYLVANIA

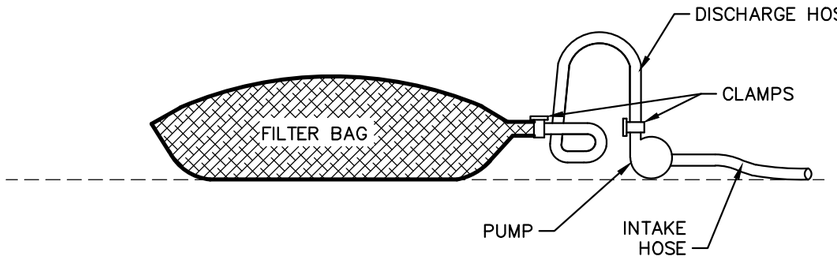
HYDROSTATIC TESTING
TYPICAL HAYBALE DISCHARGE STRUCTURE FOR PPP-PENNSYLVANIA TEST WATERS

DATE:	11/23/15
PROJECT NO.:	112IC05958
DESIGNED BY:	
DRAWN BY:	NN
CHECKED BY:	
SHEET:	1 OF 1

FIGURE 1



PLAN VIEW



ELEVATION VIEW

NOTES:

LOW VOLUME FILTER BAGS SHALL BE MADE FROM NON–WOVEN GEOTEXTILE MATERIAL SEWN WITH HIGH STRENGTH, DOUBLE STITCHED "J" TYPE SEAMS. THEY SHALL BE CAPABLE OF TRAPPING PARTICLES LARGER THAN 150 MICRONS. HIGH VOLUME FILTER BAGS SHALL BE MADE FROM WOVEN GEOTEXTILES THAT MEET THE FOLLOWING STANDARDS:

PROPERTY	TEST METHOD	MINIMUM STANDARD
AVG. WIDE WIDTH STRENGTH	ASTM D–4884	60 LB/IN
GRAB TENSILE	ASTM D–4632	205 LB
PUNCTURE	ASTM D–4833	110 LB
MULLEN BURST	ASTM D–3786	350 PSI
UV RESISTANCE	ASTM D–4355	70%
AOS % RETAINED	ASTM D–3751	80 SIEVE

A SUITABLE MEANS OF ACCESSING THE BAG WITH MACHINERY REQUIRED FOR DISPOSAL PURPOSES SHALL BE PROVIDED. FILTER BAGS SHALL BE REPLACED WHEN THEY BECOME ½ FULL OF SEDIMENT. SPARE BAGS SHALL BE KEPT AVAILABLE FOR REPLACEMENT OF THOSE THAT HAVE FAILED OR ARE FILLED. BAGS SHALL BE PLACED ON STRAPS TO FACILITATE REMOVAL UNLESS BAGS COME WITH LIFTING STRAPS ALREADY ATTACHED.

BAGS SHALL BE LOCATED IN WELL–VEGETATED (GRASSY) AREA, AND DISCHARGE ONTO STABLE, EROSION RESISTANT AREAS. WHERE THIS IS NO POSSIBLE, A GEOTEXTILE UNDERLAYMENT AND FLOW PATH SHALL BE PROVIDED. BAGS MAY BE PLACED ON FILTER STONE TO INCREASE DISCHARGE CAPACITY. BAGS SHALL NOT BE PLACED ON SLOPES GREATER THAN 5% FOR SLOPES EXCEEDING 5%, CLEAN ROCK OR OTHER NON–ERODIBLE AND NON–POLLUTING MATERIAL MAY BE PLACE UNDER THE BAG TO REDUCE SLOPE STEEPNESS.

NO DOWNSLOPE SEDIMENT BARRIER IS REQUIRED FOR MOST INSTALLATIONS. COMPOST BERM OR COMPOST FILTER SOCK SHALL BE INSTALLED BELOW BASE WHEN LOCATED IN HQ OR EV WATERSHEDS, WITHIN 50 FEET OF ANY RECEIVING SURFACE WATER OR WHERE GRASSY AREA IS NOT AVAILABLE.

THE PUMP DISCHARGE HOSE SHALL BE INSERTED INTO THE BAGS IN THE MANNER SPECIFIED BY THE MANUFACTURER AND SECURELY CLAMPED. A PIECE OF PVC PIPE IS RECOMMENDED FOR THIS PURPOSE.

THE PUMPING RATE (PER BAG) SHALL BE NO GREATER THAN 150 GPM OR ½ THE MAXIMUM SPECIFIED BY THE MANUFACTURER, WHICHEVER IS LESS.

FILTER BAGS SHALL BE INSPECTED DAILY. IF ANY PROBLEM IS DETECTED, PUMPING SHALL CEASE IMMEDIATELY AND NOT RESUME UNTIL THE PROBLEM IS CORRECTED.

PUMPED WATER FILTER BAG

NOT TO SCALE

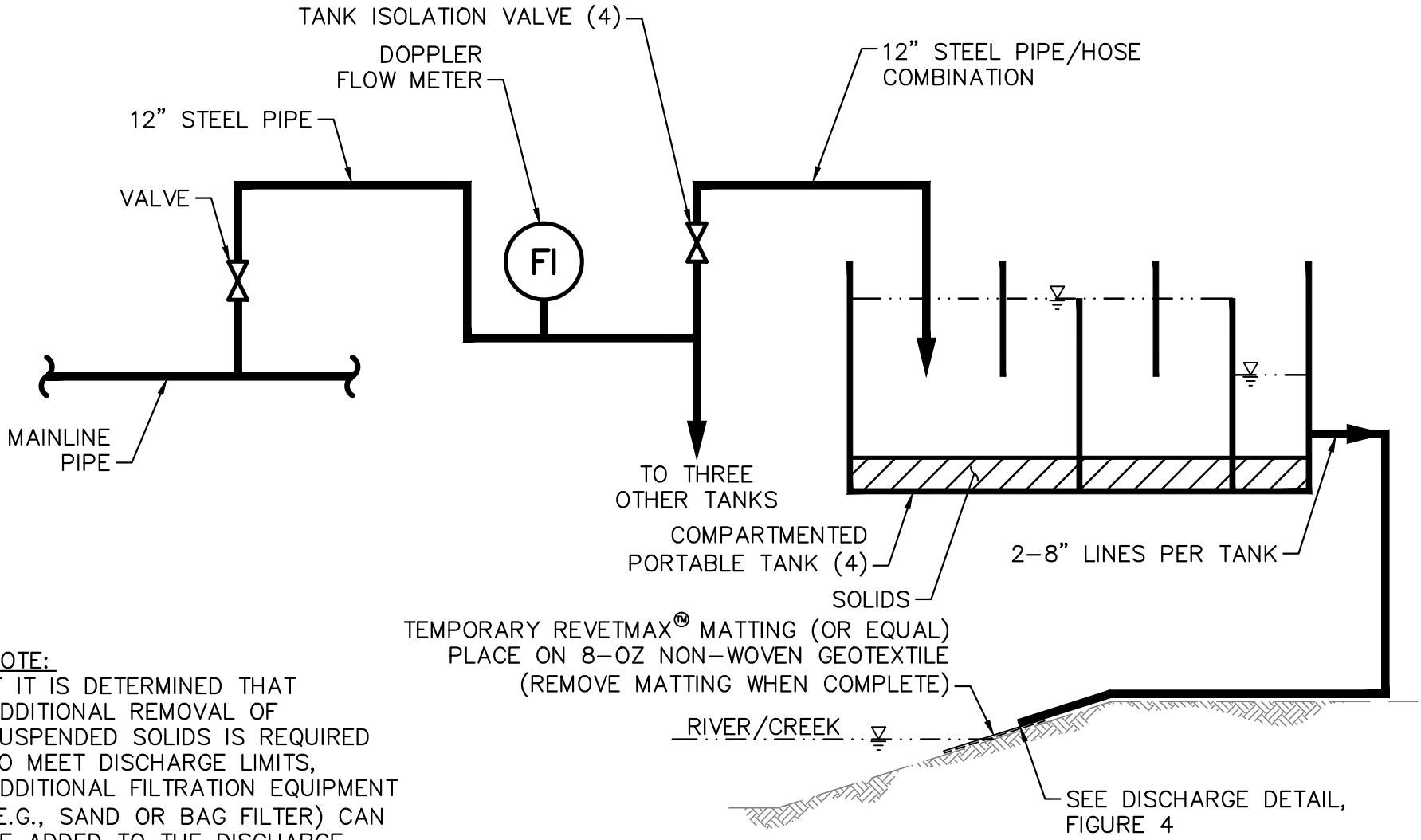
TETRA TECH
WWW.TETRATECH.COM
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921–7090 | F: (412) 921–4040

SUNOCO PIPELINE L.P.
SINKING SPRING, PENNSYLVANIA

HYDROSTATIC TESTING
DISCHARGE PLAN

DATE:	11/23/15
PROJECT NO.:	112IC05958
DESIGNED BY:	
DRAWN BY:	NN
CHECKED BY:	
SHEET:	2 OF 2

FIGURE 2



NOTE:
IF IT IS DETERMINED THAT ADDITIONAL REMOVAL OF SUSPENDED SOLIDS IS REQUIRED TO MEET DISCHARGE LIMITS, ADDITIONAL FILTRATION EQUIPMENT (E.G., SAND OR BAG FILTER) CAN BE ADDED TO THE DISCHARGE STRUCTURE ON THE DISCHARGE END OF THE PORTABLE TANKS.

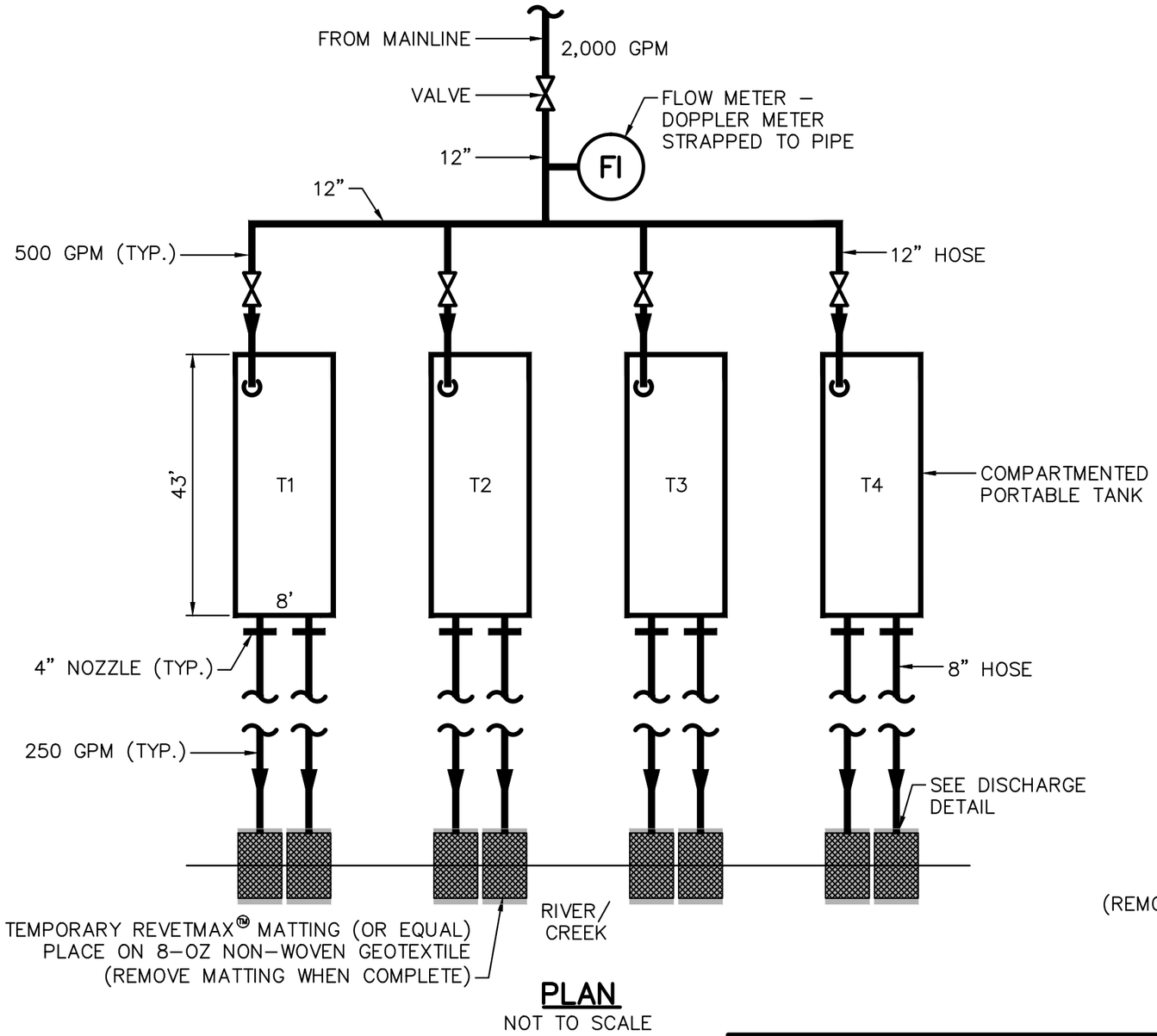
TETRA TECH
WWW.TETRATECH.COM
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921–7090 | F: (412) 921–4040

SUNOCO PIPELINE, L.P.
SINKING SPRING, PENNSYLVANIA

DIRECT HYDROTEST WATER DISCHARGE PROCESS FLOW DIAGRAM

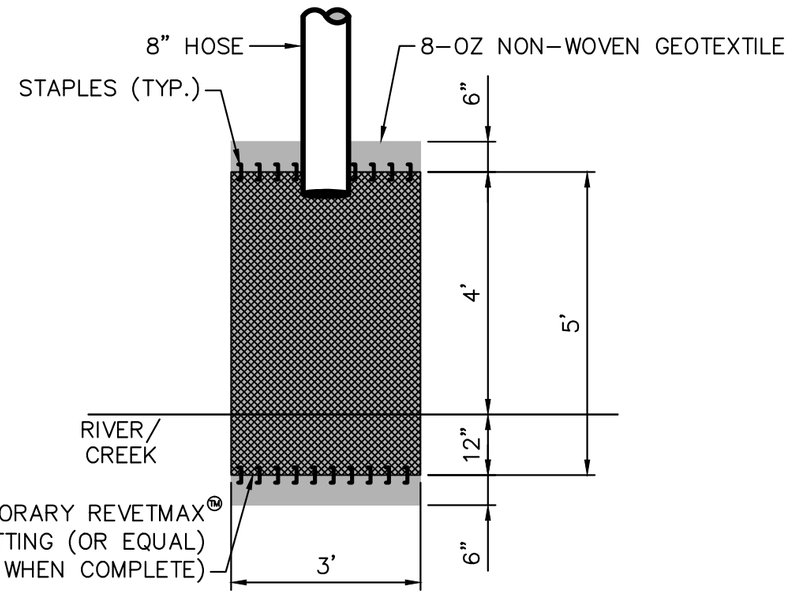
DATE:	4/6/16
PROJECT NO.:	112IC05958
DESIGNED BY:	JL
DRAWN BY:	BH
CHECKED BY:	CR
SHEET:	1 OF 2

FIGURE 3



PLAN
NOT TO SCALE

NOTE:
IF IT IS DETERMINED THAT ADDITIONAL REMOVAL OF SUSPENDED SOLIDS IS REQUIRED TO MEET DISCHARGE LIMITS, ADDITIONAL FILTRATION EQUIPMENT (E.G., SAND OR BAG FILTER) CAN BE ADDED TO THE DISCHARGE STRUCTURE ON THE DISCHARGE END OF THE PORTABLE TANKS.



DISCHARGE DETAIL
NOT TO SCALE

TETRA TECH
WWW.TETRATECH.COM
661 ANDERSEN DRIVE – FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921–7090 | F: (412) 921–4040

SUNOCO PIPELINE, L.P.
SINKING SPRING, PENNSYLVANIA

DIRECT HYDROTEST WATER DISCHARGE PLAN VIEW AND DISCHARGE DETAIL

DATE:	4/6/16
PROJECT NO.:	112IC05958
DESIGNED BY:	JL
DRAWN BY:	BH
CHECKED BY:	CR
SHEET:	2 OF 2

FIGURE 4

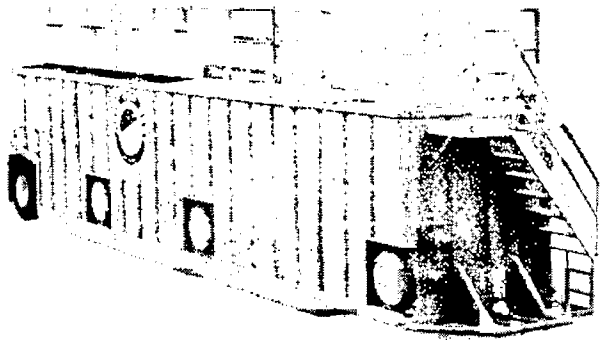
DIRECT DISCHARGE SUPPORTING MATERIAL

Steel Tank

Flip Top Weir

Overview:

18,100 gallon flip top weir tanks from Rain for Rent have a standard "V" shaped floor for ease of draining all stored liquids completely through a 4" butterfly valve with Buna seals standard.



Features:

Store liquids with confidence with Rain for Rent's 18,100 gallon flip top weir tank. Permanently attached axels for maximum maneuverability allow this 18,100 gallon tank to be moved with ease on the jobsite and a safety staircase ensures proper protection for workers on site. Internal weirs allow for extra filtration and settling of materials.

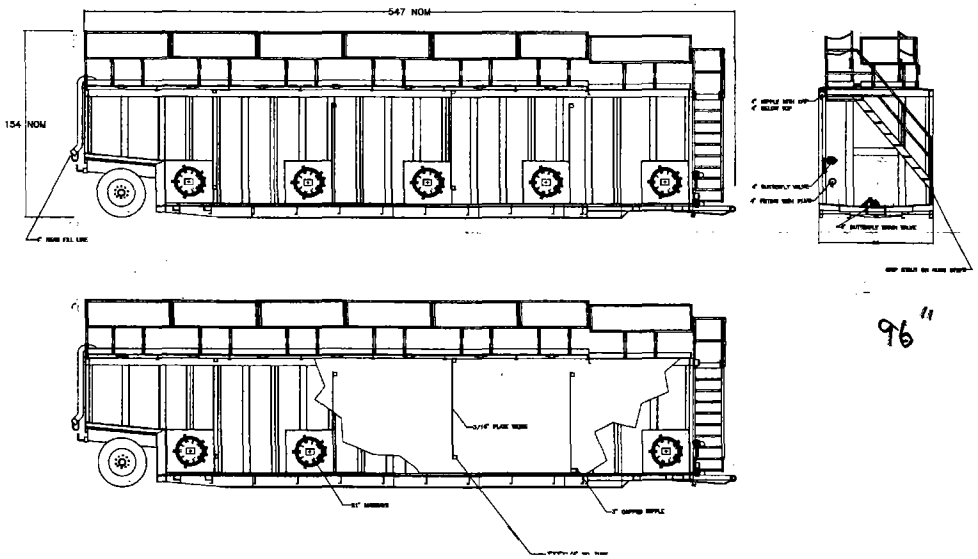
Specs:

Manways	Four 22" hatches
Material	Steel
Capacity	18,100 gallons
Dry weight	27,000 lbs.
Footprint:	516" x 96" x 126"

43' x 8' x 10.5'

Accessories:

- Spillguard
- Suction and Discharge Hoses
- Level gauges



4" Nozzles

96"

RAIN FOR RENT®

Liquid ingenuity.™

PUMPS • TANKS • FILTRATION • PIPE • SPILLGUARDS

800-742-7246
rainforrent.com

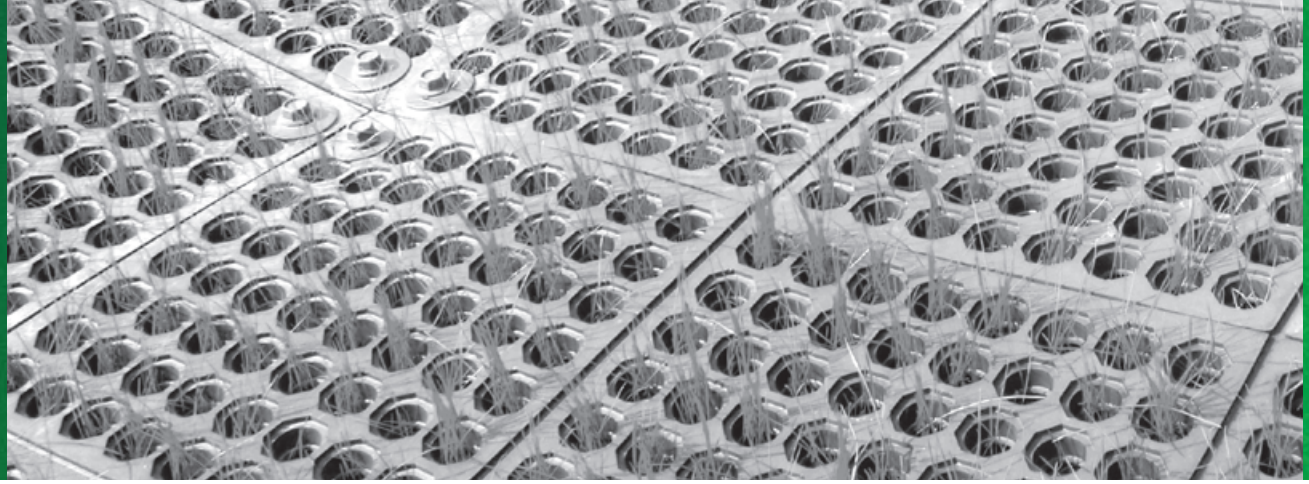
SITE OFF FLOW WEIR

REVETMAX™
FLEXIBLE REVETMENT

REVETMAX™
SHOREMAX® FLEXIBLE TRANSITION MAT

INSTALLATION GUIDE

Tensar®



Introduction to ShoreMax® Mats

RevetMax™ ShoreMax® Mats are an integrated erosion and sediment control system designed for protection of high scour and high velocity applications. The flexible transition mat can be used in varying applications and can replace hard-armor designs with "green" vegetated designs.

To create the maximum vegetated design, we suggest combining two high-performance Tensar Erosion Control Products (ECPs), the ShoreMax Mat and a VMax® Turf Reinforcement Mat (TRM). The VMax TRM's special structural design anchors and reinforces the roots and stems of vegetation for long-term stability, and helps create a shear plane that actually deflects the flowing water away from the soil surface. The ShoreMax Mat provides mechanical protection and ballasting to the protected area and can increase the immediate permissible shear stress capabilities of the system.

Depending on your project design needs, Tensar North American Green® offers many different VMax TRMs that can be used with the ShoreMax Mat to create vegetated armor systems that offer increasing performance. Once installed, the ShoreMax Mat offers protection comparable to hard-armor products such as rock riprap and articulated concrete blocks in turbulent flow and wave attack applications. The ShoreMax Mat can take your high flow projects to the maximum in green vegetated design with unvegetated shear performance up to 8.6 lbs/ft^2.

FEATURES OF SHOREMAX TRANSITION MAT

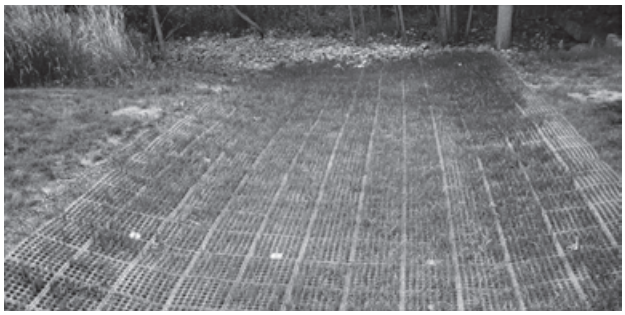
The ShoreMax Mat is the first flexible soft revetment scour protection system that easily installs over difficult soil topography, and does not require expensive earth anchors to install. The system is non-buoyant, so it won't float or uplift in submerged and heavy flow conditions. The ShoreMax Mat is designed with "grip lugs" that bite into the underlying mat that prevent horizontal shifting between the components of the ShoreMax System.

Since the ShoreMax Mat is a soft armored vegetated green design solution, it requires no heavy equipment to install; long term it has easier maintenance and offers greater safety for vehicle and pedestrian traffic. The vegetated design also increases water infiltration and water filtration resulting in reduced and cleaner storm water runoff.

KEY APPLICATIONS

The RevetMax systems are designed for immediate to permanent protection for high scour applications such as head-to-tail protection of drainage channels, culvert and pipe outfalls, and steep chute and slope drains like those associated with parking lots, roadways, mines and landfills. The flexible transition mat can also offer effective erosion and sediment control to create soft revetment systems. The ShoreMax Mat can be utilized for shorelines, streambanks, and spillway applications where wave attack can reach the super critical stage.

The ShoreMax Transition Mat is a smart option to replace rock in high scour areas such as pipe outlets.



RevetMax ShoreMax Transition Mats facilitate vegetation growth through voids in the mat.

MAXIMUM DESIGN CONDITIONS			Anchor Pattern
Shear Stress	Velocity	Wave Height	
≤6 lbs/ft²	≤14 ft/s	6 in.	F
>6–8 lbs/ft²	>14-18 ft/s	12 in.	G
>8 lbs/ft²	>18 ft/s	18 in.	H

TABLE *Minimum anchor pattern*

MINIMUM ANCHOR TYPE BASED ON SOIL TYPE	
Soil Type	Anchor Type
Clay – Clay Loam	10 in. Wire Staple or 12 in. ShoreMax Stake
Silt Loam – Loam	10 in. Wire Staple or 12 in. ShoreMax Stake
Sandy Loam	12 in. Wire Staple or 12 in. ShoreMax Stake
Sand/Muck ≤6 in.	12 in. Rebar Staple
Sand/Muck 6-12 in.	18 in. Rebar Staple
Sand/Muck 12-18 in.	Earth Anchor 400 + 12 in. Rebar Staple
Sand/Muck >18 in.	Earth Anchor 680 + 18 in. Rebar Staple

TABLE 2: *Minimum anchor type*

RevetMax™ ShoreMax® Anchoring Guidelines

Installation of the ShoreMax® Mat can be done simply and without the need for expensive equipment. The ShoreMax Mat and TRM underlayment are simply installed over a prepared seeded soil and fastened into place with anchors.

The flexibility of the ShoreMax Mats allows them to be easily installed with a variety of fasteners such as the ShoreMax stake, wire staples, rebar staples and percussion earth anchors. Since the ShoreMax Mat easily self-conforms to the underlying terrain, fasteners are not required to force conformance with the underlayment material – they only serve to hold the panels in place. Therefore, special percussion earth anchors are typically not required. The type and size of fastener used is simply dependent upon the underlying soil and degree of compaction.

Anchoring patterns for the ShoreMax Mat will vary depending on the project applications with increased anchoring patterns required for higher flow or scour applications. The following charts will help decipher the appropriate anchor type and anchor pattern. For site-specific recommendations use the Erosion Control Materials Design Software (ECMDS) for help in selecting a RevetMax System and fastening details. Visit www.ecmds.com for more information.

ANCHORING GUIDE

1. When installing ShoreMax Mat, the anchor pattern (Figures 1 or 2) should be selected based on the expected maximum design conditions (shear stress, velocity or wave impact) (Table 1).

   Anchor selection should be based on the soil type and pull-out strength required (Table 2). In soft, highly erodible soils percussion earth anchors may be necessary. Earth anchors can be installed in conjunction with staples (Figure 2).

   When using percussion earth anchors, position anchors in each corner and the center of the panel. Place staples in the appropriate pattern through remainder of mat. Staples can be shared between two adjacent panels.

***NOTE:** Number of staples used per panel can be reduced by 30-40 percent when sharing staples between panels.*

⊓ – Staple/Stake ⊕ – Percussion Earth Anchor

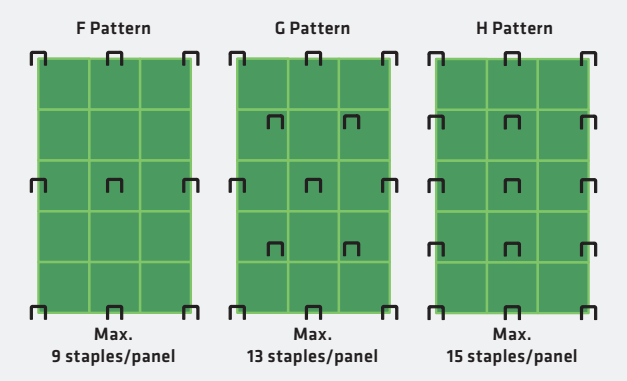


FIGURE 1 : *Anchor Patterns for use with staples/stakes*

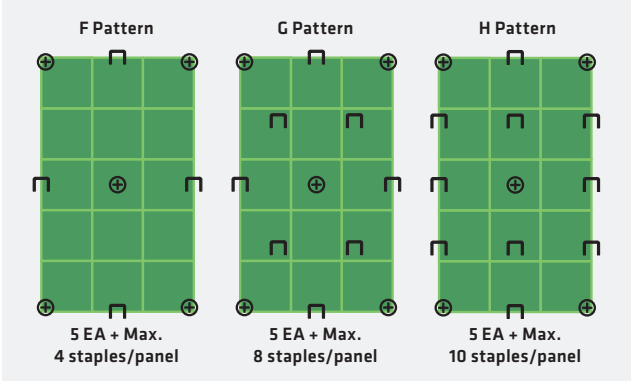


FIGURE 2: *Anchor Patterns for use with a combination of earth anchors and staples*

Channel Design Guideline

The ShoreMax® Mat has been evaluated for its performance in high-performance channelized applications, resulting in the following design guidelines:

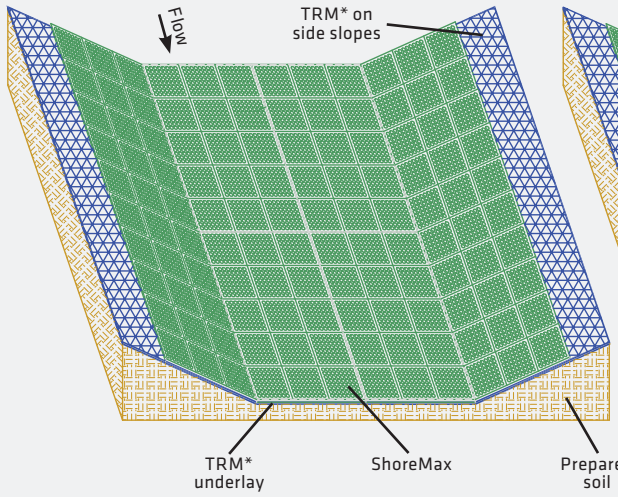


FIGURE 3: *Steep channel*

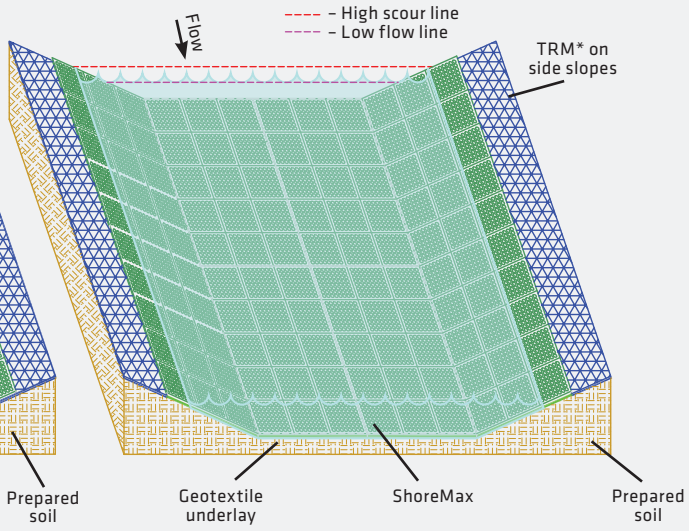


FIGURE 4: *Continuous flow channel*

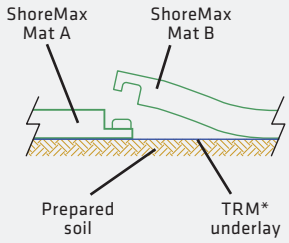


FIGURE 5: *Integrated panel interlock system*

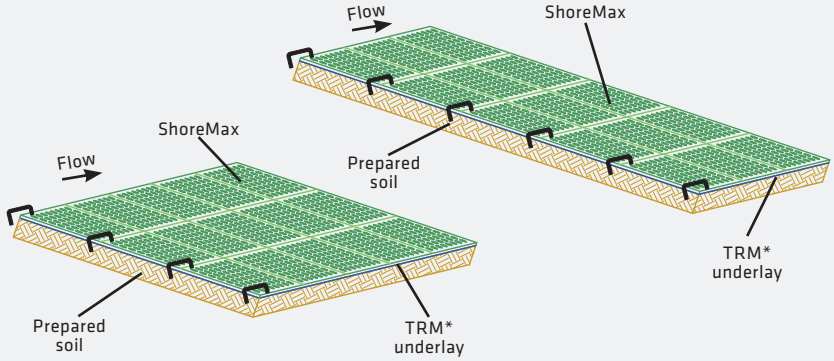


FIGURE 6: *Leading edge anchoring*

STEEP CHANNEL/CHUTE SPILLWAY DETAIL

** ShoreMax® Mats can be installed over a variety of underlayments including: sod, TRMs, geotextiles, and in some cases Erosion Control Blankets (ECBs).*

1. Prepare soil before installing erosion control products, including any necessary application of lime, fertilizer and seed (when installing TRM or ECB underlayment).

   Install TRM over prepared soils according to manufacturer's recommendations.

   Place ShoreMax Mat in the bottom of the channel over the installed TRM (Figure 3). The ShoreMax Mat should be installed up to the appropriate elevation on the side slope as determined by the engineer. When using multiple panels, connect the panels using the Integrated Panel Interlock System (Figure 5). ShoreMax Mat can be laid in either direction.

   For channels carrying continuous water flows, an appropriate geotextile should be placed under the ShoreMax Mat for submerged applications (Figure 4).

   Place staples/anchors in the appropriate pattern. Perimeter staples can be shared between two adjacent panels. In soft or highly erodible soils, percussion earth anchors may be required. View ShoreMax Anchoring Guide for additional details.

   At beginning of channel and areas where significant concentrated flows are directed onto the ShoreMax Mat, place one staple/pin per linear foot along the leading edge of the ShoreMax System, resulting in one staple/pin on each corner and gridline (Figure 6).

OUTLET CULVERT PROTECTION DETAIL

** ShoreMax® Mats can be installed over a variety of underlayments including: sod, TRMs, geotextiles, and in some cases ECBs.*

1. Prepare soil before installing erosion control products, including any necessary application of lime, fertilizer, and seed (when installing with a TRM or ECB).

   Install TRM over prepared soils according to manufacturer's recommendations.

   Place ShoreMax Mat over the installed TRM (Figure 7). When using multiple panels, connect the panels using the Integrated Panel Interlock System (Figure 5). ShoreMax Mat can be laid in either direction.

For culvert and outfall applications, ShoreMax Transition Mat scour protection should extend a minimum width of 3-4 times the pipe diameter and a minimum length of 4-5 times the pipe diameter (Figure 7). With steeper channel gradients, the length of scour protection may need to be extended.

Place staples/anchors in the appropriate pattern. Perimeter staples can be shared between two adjacent panels. In soft or highly erodible soils, percussion earth anchors may be required. View ShoreMax Anchoring Guide for additional details.

Place one staple/pin per linear foot along the leading edge of the ShoreMax System, resulting in one staple/pin on each corner and gridline (Figure 6).

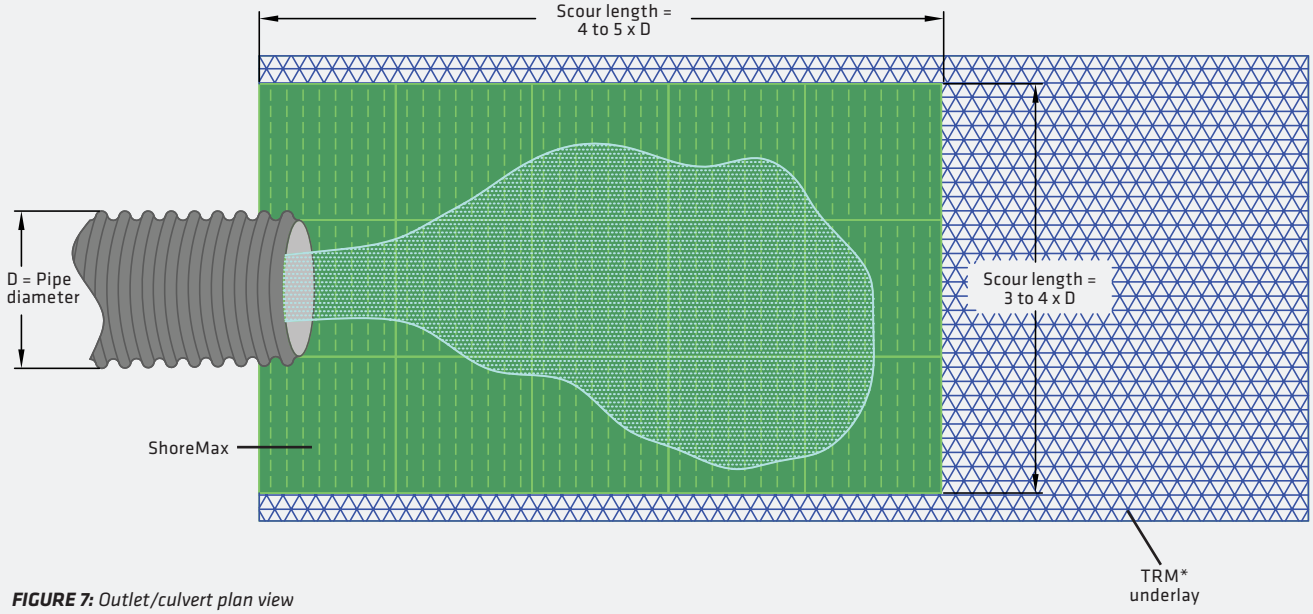


FIGURE 7: *Outlet/culvert plan view*

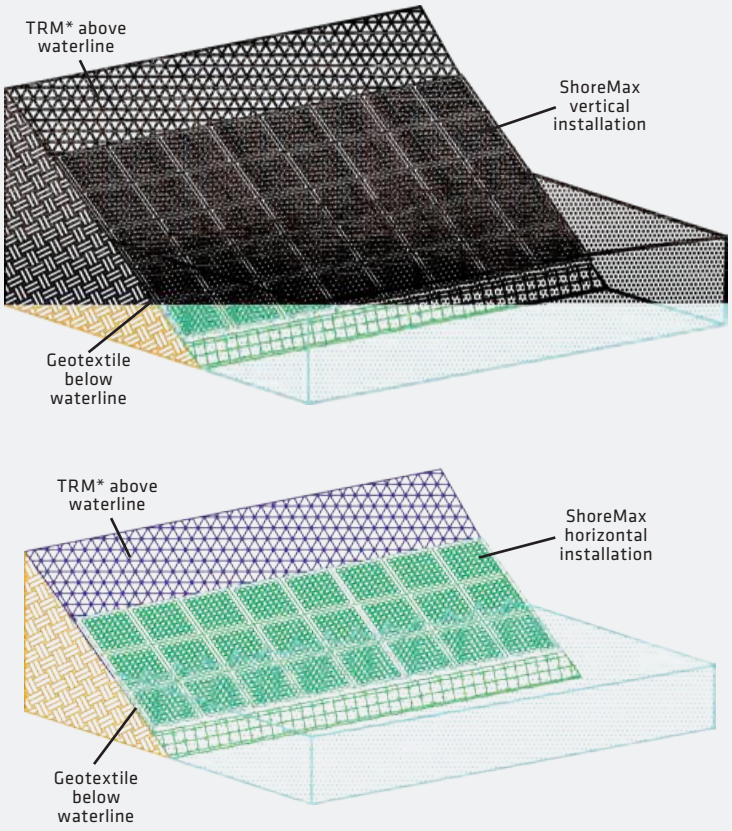


FIGURE 8: *Shoreline/Streambank plan view*
**ShoreMax Mats can be placed on slope in either direction.*

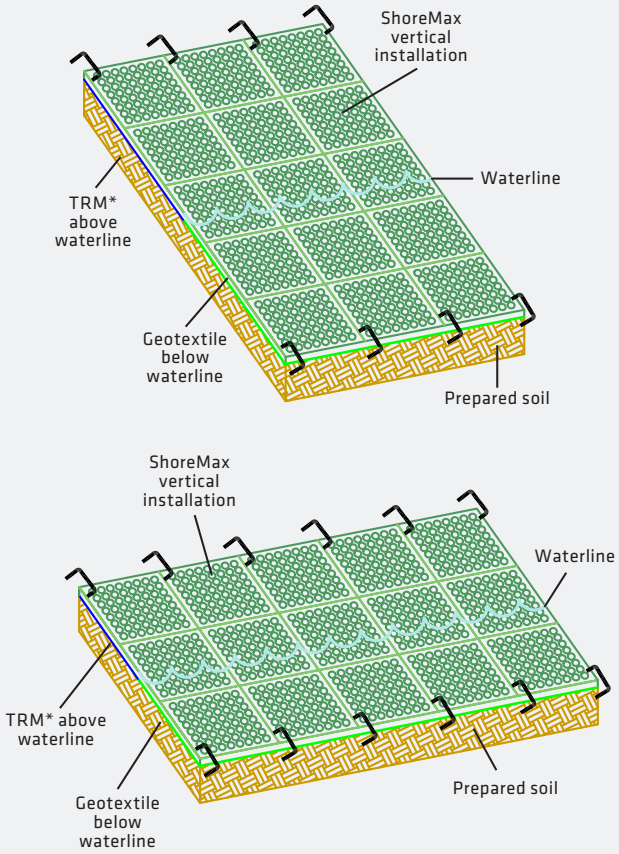


FIGURE 9: *Edge of mat anchoring*

SHORELINE/STREAMBANK/LEVEE DETAIL

** ShoreMax® Mats can be installed over a variety of underlayments including: sod, TRMs, geotextiles, and in some cases ECBs.*

1. Prepare soil before installing erosion control products, including any necessary application of lime, fertilizer and seed (when installing TRMs or ECBs underlayment).

   Install TRM above the waterline following manufacturer's recommendations.

NOTE: *A bottom anchor trench is not required when using ShoreMax Mat in conjunction with a TRM or geotextile.*

3. In areas below the normal water elevation, an appropriate geotextile should be installed beneath the ShoreMax Mat.

   Place ShoreMax Mat over the installed TRM or geotextile (Figure 8). When using multiple panels, connect the panels using the Integrated Panel Interlock System (Figure 5). ShoreMax Mat can be laid in either direction (Figures 8 and 9).

   Extend the ShoreMax Mat to cover the transitional range where scour is predicted based on typical water level fluctuations and wave lap.

   Place staples/anchors in the appropriate pattern. Perimeter staples can be shared between two adjacent panels. In soft or highly erodible soils, percussion earth anchors may be required. View ShoreMax Anchoring Guide for additional details.

   Place one staple/pin per linear foot along the top and bottom edges of the ShoreMax System, placing one on each corner and gridline (Figure 9).

EXPERIENCE YOU CAN RELY ON:

Tensar is the industry leader when it comes to providing comprehensive erosion and sediment control and turf reinforcement solutions as well as internal soil reinforcement solutions for site development challenges. We have developed integrated systems and products with the sole objective to ensure absolute customer satisfaction. Our products are backed by the most thorough quality assurance practices in the industry. And, we provide comprehensive design assistance for every Tensar system.

For additional installation assistance on RevetMax™ Systems, please call **800-TENSAR-1**, visit **www.tensarcorp.com** or e-mail **info@tensarcorp.com** and we will be happy to put you in touch with your erosion control specialist who can assist you.

RECP REMAX® TRANSITION MAT DESIGN CRITERIA

Underlayment Type and Phase		Maximum Permissible Shear Stress	Maximum Flow Velocity	Maximum Wave Attack Applications		
SC250	Unvegetated	7.5 lbs/ft^2	18 ft/s	6 in. wave height, ≤4:1 slope	12 in. wave height, ≤5:1 slope	N/A
	Vegetated	10 lbs/ft^2	18 ft/s			
C350	Unvegetated	8.0 lbs/ft^2	19 ft/s	6 in. wave height, ≤3:1 slope	12 in. wave height, ≤4:1 slope	N/A
	Vegetated	12 lbs/ft^2	20 ft/s			
P550	Unvegetated	8.5 lbs/ft^2	19.5 ft/s	6 in. wave height, ≤2:1 slope	12 in. wave height, ≤3:1 slope	18 in. wave height, ≤5:1 slope
	Vegetated	14 lbs/ft^2	25 ft/s			

The ShoreMax Transition Mat has been evaluated for its performance in conjunction with a VMax TRM in both channel and wave attack applications, resulting in these guidelines.

REVETMAX™
FLEXIBLE REVETMENT

Specification Sheet – ShoreMax® Transition Mat

DESCRIPTION

The ShoreMax transition protection mat shall be a resilient rubber mat with surface texture and multi-nib backing. It shall have a large hole drainage system with aperture openings approximately 0.88 in (2.24 cm) in diameter. ShoreMax mat is a transition mat used as biotechnical replacement for hard armor. ShoreMax mat is mechanically anchored and is a flexible matting that can be linked together. ShoreMax mat can provide erosion control in highly erosive areas, including shorelines, and can be used in conjunction with rolled erosion control products.

Material Content		
Matting	100% UV-stabilized natural rubber	2.65 lbs/sf (12.82 kg/sm)
Color	Dark green or tan	

Standard Roll Sizes	
Width	3.0 ft (1.0 m)
Length	5.0 ft (1.5 m)
Weight ± 10%	39 lbs (17.69 kg)
Area	1.67 sy (1.39 sm)

Design Permissible Shear Stress			
Underlayment Type and Phase		**Maximum Permissible Shear Stress**	**Maximum Flow Velocity**
SC250	**Unvegetated**	**7.5 psf**	18 fps
	Vegetated	**10.0 psf**	18 fps
C350	**Unvegetated**	**8.0 psf**	19 fps
	Vegetated	**12.0 psf**	20 fps
P550	**Unvegetated**	**8.5 psf**	19.5 fps
	Vegetated	**14.0 psf**	25 fps

Index Property	Test Method	Typical
Thickness	ASTM D6525	0.75 in. (19.0 mm)
Density	ASTM D792	1.628 oz/in^3
Mass/Unit Area	ASTM D6566	2.65 lb/sf (13.25 kg/sm)
UV Stability	ASTM D4355 /1000 hr	90-100%
Ground Cover	ASTM D6567	79.3%
Light Penetration	ASTM D6567	20.7%
Hardness	ASTM D2240	68
Specific Gravity	ASTM D792	1.566 g/cm^3
Flexural Rigidity	ASTM D6575	1.97 in-lbs
Tensile Strength - MD	ASTM D6818	612 lbs/ft (9.07 kN/m)
Elongation - MD	ASTM D6818	102%
Tensile Strength - TD	ASTM D6818	560 lbs/ft (8.30 kN/m)
Elongation - TD	ASTM D6818	96%
Biomass Improvement	ASTM D7322	243 %

NTPEP ASTM D6460 Large Scale Channel*	
Unvegetated Shear Stress	8.6 psf (412 Pa)
Vegetated Shear Stress	> 12.5 psf (599 Pa)
Unvegetated Velocity	19.5 fps (5.95 m/s)
Vegetated Velocity	> 26.0 fps (7.93 m/s)

**Testing conducted with ShoreMax installed over P550*

Tensar®
NORTH AMERICAN GREEN®

Tensar International Corporation
2500 Northwinds Parkway
Suite 500
Alpharetta, GA 30009
800-TENSAR-1
tensarcorp.com

FRICTION LOSS IN WATER HOSE
POUNDS PER SQUARE INCH PER 100 FOOT LENGTH
STRAIGHT-SMOOTH BORE

Flow of Water in U.S. Gal. Per Min.	ACTUAL INTERNAL DIAMETER — INCHES														
	1/2	5/8	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6	8	10	12
1	1.41														
2	5.09	1.72	0.71												
5	27.7	9.36	3.85	0.95	0.32	0.13									
10	100	33.7	13.9	3.42	1.15	0.47	0.12								
15		71.4	29.4	7.24	2.44	1.00	0.25	0.08							
20		122	50.0	12.3	4.16	1.71	0.42	0.14							
25			75.6	18.6	6.28	2.59	0.64	0.21							
30			106	26.1	8.80	3.62	0.89	0.30	0.12						
35			141	34.7	11.7	4.82	1.19	0.40	0.16						
40				44.4	15.0	6.17	1.52	0.51	0.21						
45				55.3	18.6	7.67	1.89	0.64	0.26						
50				67.1	22.7	9.32	2.30	0.77	0.32						
60				94.1	31.7	13.1	3.22	1.09	0.45						
70				125	42.2	17.4	4.28	1.44	0.59						
80					54.0	22.2	5.48	1.85	0.76						
90					67.2	27.7	6.81	2.30	0.95	0.23					
100					81.7	33.6	8.28	2.79	1.15	0.28					
125					123	50.8	12.5	4.22	1.74	0.43					
150						71.1	17.5	5.91	2.43	0.60	0.20				
175						94.6	23.3	7.86	3.24	0.80	0.27				
200						121	29.8	10.1	4.14	1.02	0.34				
225							37.1	12.5	5.15	1.27	0.43				
250							45.1	15.2	6.26	1.54	0.52				
275							53.8	18.1	7.47	1.84	0.62				
300							63.2	21.3	8.77	2.16	0.73	0.30			
350							84.0	28.3	11.7	2.87	0.97	0.40			
400							108	36.3	14.9	3.68	1.24	0.51			
450								45.1	18.6	4.57	1.54	0.64			
500								54.8	22.6	5.56	1.88	0.77	0.19		
600								76.8	31.6	7.79	2.63	1.08	0.27		
700								102	42.1	10.4	3.49	1.44	0.35	0.12	
800								131	53.8	13.3	4.47	1.84	0.45	0.15	
1000									81.4	20.0	6.76	2.78	0.69	0.23	0.10
1200									114	28.1	9.47	3.90	0.96	0.32	0.13
1400									152	37.3	12.6	5.18	1.28	0.43	0.18
1600										47.8	16.1	6.64	1.64	0.55	0.23
1800										59.5	20.0	8.25	2.03	0.69	0.28
2000										72.2	24.4	10.0	2.47	0.83	0.34
2500											36.8	15.2	3.75	1.26	0.52
3000											51.6	21.2	5.23	1.76	0.73

To convert PSI to Megapascals (MPa) multiply by 0.006895
To convert from PSI to feet of Hydraulic Head multiply by 2.309
To convert from U.S. gallons per minute to cubic feet per minute multiply by 0.1337
To convert from U.S. gallons per minute to cubic meters per second multiply by .00006309

NOTE: Friction loss can vary by 20% due to temperature. Bends can increase friction loss by 50%.

C value is the Hazen-Williams coefficient; smaller values must be used for rougher tube surfaces.

$$\triangle P = 4.51(Q/C)^{1.85} \times \frac{L}{d^{4.87}} \quad \text{or} \quad \triangle P = \frac{0.0483Q}{d^{4.87}} \quad @60^{\circ}F (15.6^{\circ}C)$$

where : P= pressure loss in lbs. per square inch
Q=quantity in U.S. gallons per minute
C=140 for clean, extremely smooth bore and straight hose
L=Length of hose in feet
d=inside diameter of hose in inches

***Charts are provided by Rubbers Manufacturers Association**

U.S. Gallons per Minute	2 In. (2.067" I.D.)			2½ In. (2.469" I.D.)			3 In. (3.068" I.D.)			3½ In. (3.548" I.D.)			U.S. Gallons per Minute
	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
30	2.87	0.128	1.82	2.01	0.063	0.75							30
35	3.35	0.174	2.42	2.35	0.085	1.00							35
40	3.82	0.227	3.10	2.68	0.112	1.28							40
50	4.78	0.355	4.67	3.35	0.174	1.94	2.17	0.073	0.66				50
60	5.74	0.511	6.59	4.02	0.251	2.72	2.60	0.105	0.92	1.95	0.059	0.45	60
80	7.65	0.909	11.4	5.36	0.447	4.66	3.47	0.187	1.57	2.60	0.105	0.77	80
100	9.56	1.42	17.4	6.70	0.698	7.11	4.34	0.293	2.39	3.25	0.164	1.17	100
120	11.5	2.05	24.7	8.04	1.00	10.0	5.21	0.421	3.37	3.89	0.236	1.64	120
140	13.4	2.78	33.2	9.38	1.37	13.5	6.08	0.574	4.51	4.54	0.321	2.18	140
160	15.3	3.64	43.0	10.7	1.79	17.4	6.94	0.749	5.81	5.19	0.419	2.80	160
180	17.2	4.60	54.1	12.1	2.26	21.9	7.81	0.948	7.28	5.84	0.530	3.50	180
200	19.1	5.68	66.3	13.4	2.79	26.7	8.68	1.17	8.90	6.49	0.655	4.27	200
220	21.0	6.88	80.0	14.7	3.38	32.2	9.55	1.42	10.7	7.14	0.792	5.12	220
240	22.9	8.18	95.0	16.1	4.02	38.1	10.4	1.69	12.6	7.79	0.943	6.04	240
260	24.9	9.60	111	17.4	4.72	44.5	11.3	1.98	14.7	8.44	1.11	7.04	260
280	26.8	11.1	128	18.8	5.47	51.3	12.2	2.29	16.9	9.09	1.28	8.11	280
300	28.7	12.8	146	20.1	6.28	58.5	13.0	2.63	19.2	9.74	1.47	9.26	300
350				23.5	8.55	79.2	15.2	3.57	26.3	11.3	2.00	12.4	350
400				26.8	11.2	103	17.4	4.68	33.9	13.0	2.62	16.2	400
500				33.5	17.4	160	21.7	7.32	52.5	16.2	4.09	25.0	500
600							26.0	10.5	74.8	19.5	5.89	35.6	600
700							30.4	14.3	101	22.7	8.02	48.0	700
800							34.7	18.7	131	26.0	10.5	62.3	800
1000										32.5	16.4	96.4	1000

U.S. Gallons per Minute	4 In. (4.026" I.D.)			5 In. (5.047" I.D.)			6 In. (6.065" I.D.)			8 In. (7.981" I.D.)			U.S Gallons per Minute
	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
140	3.53	0.193	1.16	2.25	0.078	0.38							140
160	4.03	0.253	1.49	2.57	0.102	0.49							160
180	4.54	0.320	1.86	2.89	0.129	0.61							180
200	5.04	0.395	2.27	3.21	0.160	0.74	2.22	0.077	0.30				200
240	6.05	0.569	3.21	3.85	0.230	1.03	2.66	0.110	0.42				240
280	7.06	0.774	4.30	4.49	0.313	1.38	3.11	0.150	0.56				280
320	8.06	1.01	5.51	5.13	0.409	1.78	3.55	0.196	0.72				320
360	9.07	1.28	6.92	5.77	0.518	2.22	4.00	0.240	0.90				360
400	10.1	1.58	8.47	6.41	0.639	2.72	4.44	0.307	1.09	2.57	0.102	0.28	400
450	11.3	2.00	10.5	7.23	0.811	3.42	5.00	0.388	1.37	2.89	0.129	0.35	450
500	12.6	2.47	13.0	8.02	0.999	4.16	5.55	0.479	1.66	3.21	0.160	0.42	500
600	15.1	3.55	18.6	9.62	1.44	5.88	6.66	0.690	2.34	3.85	0.230	0.60	600
700	17.6	4.84	25.0	11.2	1.96	7.93	7.77	0.939	3.13	4.49	0.313	0.80	700
800	20.2	6.32	32.4	12.8	2.56	10.2	8.88	1.23	4.03	5.13	0.409	1.02	800
900	22.7	8.00	40.8	14.4	3.24	12.9	9.99	1.55	5.05	5.77	0.518	1.27	900
1000	25.2	9.87	50.2	16.0	4.00	15.8	11.1	1.92	6.17	6.41	0.639	1.56	1000
1200	30.2	14.2	72.0	19.2	5.76	22.5	13.3	2.76	8.76	7.70	0.920	2.20	1200
1400	35.3	19.3	97.6	22.5	7.83	30.4	15.5	3.76	11.8	8.98	1.25	2.95	1400
1600				25.7	10.2	39.5	17.8	4.91	15.4	10.3	1.64	3.82	1600
1800				28.8	12.9	49.7	20.0	6.21	19.4	11.5	2.07	4.79	1800
2000				32.1	16.0	61.0	22.2	7.67	23.8	12.8	2.56	5.86	2000
2400							26.6	11.0	34.2	15.4	3.68	8.31	2400
2800							31.1	15.0	46.1	18.0	5.01	11.2	2800
3200							35.5	19.6	59.9	20.5	6.55	14.5	3200
3600										23.1	8.28	18.4	3600
4000										25.7	10.2	22.6	4000

U.S. Gallons per Minute	10 In. (10.020" I.D.)			12 In. (11.938" I.D.)			14 In. (13.124" I.D.)			16 In. (15.000" I.D.)			U.S. Gallons per Minute
	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
800	3.25	0.165	0.328										800
900	3.66	0.208	0.410	2.58	0.103	0.173							900
1000	4.07	0.257	0.500	2.87	0.128	0.210	2.37	0.087	0.131				1000
1200	4.88	0.370	0.703	3.44	0.184	0.296	2.85	0.126	0.185				1200
1400	5.70	0.504	0.940	4.01	0.250	0.395	3.32	0.171	0.247				1400
1600	6.51	0.659	1.21	4.59	0.327	0.509	3.79	0.224	0.317	2.90	0.131	0.163	1600
1800	7.32	0.834	1.52	5.16	0.414	0.636	4.27	0.283	0.395	3.27	0.166	0.203	1800
2000	8.14	1.03	1.86	5.73	0.511	0.776	4.74	0.349	0.483	3.63	0.205	0.248	2000
2500	10.2	1.62	2.86	7.17	0.799	1.19	5.93	0.546	0.738	4.54	0.320	0.377	2500
3000	12.2	2.32	4.06	8.60	1.15	1.68	7.11	0.786	1.04	5.45	0.461	0.535	3000
3500	14.2	3.13	5.46	10.0	1.55	2.25	8.30	1.07	1.40	6.35	0.627	0.718	3500
4000	16.3	4.12	7.07	11.5	2.04	2.92	9.48	1.40	1.81	7.26	0.820	0.921	4000
4500	18.3	5.21	8.88	12.9	2.59	3.65	10.7	1.77	2.27	8.17	1.04	1.15	4500
5000	20.3	6.43	10.9	14.3	3.19	4.47	11.9	2.18	2.78	9.08	1.28	1.41	5000
6000	24.4	9.26	15.6	17.2	4.60	6.39	14.2	3.14	3.95	10.9	1.84	2.01	6000
7000	28.5	12.6	21.1	20.1	6.26	8.63	16.6	4.28	5.32	12.7	2.51	2.69	7000
8000	32.5	16.5	27.5	22.9	8.17	11.2	19.0	5.59	6.90	14.5	3.28	3.49	8000
9000	36.6	20.8	34.6	25.8	10.3	14.1	21.3	7.08	8.7	16.3	4.15	4.38	9000
10,000				28.7	12.8	17.4	23.7	8.74	10.7	18.2	5.12	5.38	10,000
12,000				34.4	18.3	24.8	28.5	12.6	15.2	21.8	7.38	7.69	12,000
14,000				40.1	25.0	33.5	33.2	17.1	20.7	25.4	10.0	10.4	14,000
16,000							37.9	22.4	26.8	29.0	13.1	13.5	16,000
18,000							42.7	28.3	33.9	32.7	16.6	17.2	18,000
20,000										36.3	20.5	21.2	20,000

U.S. Gallons per Minute	18 In. (16.876" I.D.)			20 In. (18.812" I.D.)			24 In. (22.624" I.D.)			U.S. Gallons per Minute
	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	V	$\frac{V^2}{2g}$	h_f	
2000	2.87	0.128	0.139							2000
3000	4.30	0.288	0.297	3.46	0.186	0.174				3000
4000	5.74	0.512	0.511	4.62	0.331	0.298	3.19	0.158	0.120	4000
5000	7.17	0.799	0.781	5.77	0.517	0.455	3.99	0.247	0.181	5000
6000	8.61	1.15	1.11	6.92	0.745	0.645	4.79	0.356	0.257	6000
8000	11.5	2.05	1.93	9.23	1.32	1.11	6.38	0.633	0.441	8000
10,000	14.3	3.20	2.97	11.5	2.07	.70	7.98	0.989	0.671	10,000
12,000	17.2	4.60	4.21	13.8	2.98	2.44	9.58	1.42	0.959	12,000
14,000	20.1	6.27	5.69	16.2	4.06	3.29	11.2	1.94	1.29	14,000
16,000	22.9	8.19	7.41	18.5	5.30	4.26	12.8	2.53	1.67	16,000
18,000	25.8	10.4	9.33	20.8	6.71	5.35	14.4	3.21	2.10	18,000
20,000	28.7	12.8	11.5	23.1	8.28	6.56	16.0	3.96	2.58	20,000
22,000	31.6	15.5	13.9	25.4	10.0	7.91	17.6	4.79	3.10	22,000
24,000	34.4	18.4	16.5	27.7	11.9	9.39	19.2	5.70	3.67	24,000
26,000	37.3	21.6	19.2	30.0	14.0	11.0	20.7	6.69	4.29	26,000
28,000	40.2	25.1	22.2	32.3	16.2	12.7	22.3	7.76	4.96	28,000
30,000	43.0	28.8	25.5	34.6	18.6	14.6	23.9	8.91	5.68	30,000
34,000				39.2	23.9	18.7	27.1	11.4	7.22	34,000
38,000				43.9	29.9	23.2	30.3	14.3	9.00	38,000
42,000							33.5	17.5	11.0	42,000
46,000							36.7	20.9	13.2	46,000
50,000							39.9	24.7	15.5	50,000