FINAL PLAN

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* Foundation Stabilization-Piers-Soil Nails
* Passive Ventilating Vapor Barriers (PVVB)
* Water Reservoir Tank Linings (Exterior/Interior)
* Foundation Drainage and Waterproofing Systems
* Plaza Deck Waterproofing and Concrete Restoration

January 9th, 2020

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Project: 5992-09-82/83/85/86/87/88, CTH M
Raymond Road, Unacceptable Storm Sewer Pipe
Subject: Concrete Pipe Tunnel Restoration Plan

Gentlemen:

This cover letter will provide an executive summary of the Raymond Road Elliptical Pipe Restoration work. BDA Associates, LLC objective was to provide a design:

1.) to mitigate sand piping and active water leakage at joints and cracks, and
2.) increase soil bearing resistance from pipe invert to springlines.

* Hazardous Gas Control
* Air & Vapor Barrier
* Soil Solidification
* Expansion Joints
* Chemical Grouting
* Forensic Engineering
* Green Roofing
* Single Ply Roofing

Based on information and reports provided by the following entities:

1.) AET (Tested on 04/24/19 and reported on 05/15/19),
2.) NORCON (Inspected on 10/30/18 and reported on 10/31/18),
3.) SGH (tested on 07/28&29/19 and reported 08/29/19),
4.) Barr Engineering (Tested (06 & 07)/2019) and reported 07/06/19) and further Reports on (08/01/2019),

we determined that an effective interior pipe joint seal would be very difficult to achieve long term.

The most effective pipe joint seal would be via chemical grouting the internal pipe joint (interception grouting) with additional soil solidification (permeation grouting) behind (soil side) of exposed joint. This type of seal will have a long-life expectancy and work in both negative and/or positive side water pressurization. This type of seal will substantially be more effective long term than the designed asphaltic seal. In fact, after successful completion of herein designed grouting techniques per our plans and specifications, the Owner will have a water and sand piping control system exceeding the original design.

For an exterior pipe seal to be effective long term against internal water pressurization, the soil adjacent to the solidified soil must be stable and without voids. Further, pipe segments must be adequately supported against excessive movement near the crown and springlines to additionally ensure stability of the solidified soil pipe seal.

With an effective exterior pipe seal, little interior work needs to be done to remediate loss of asphalt mastic in pipe joints. Our design incorporates a membrane gland when the pipe joint exceeds 1.50 inches in width. This membrane acts as a secondary gland to the primary seal on pipe exterior.

After visually examining the elliptical concrete pipe tunnel on October 29, 2019 it confirmed and verified my opinion(s) regarding the pipe joint conditions.

The design goal of this project is to enhance the service life via increasing durability and performance of Raymond Road elliptical concrete pipe. Chemical grouting at pipe joints and cementitious grouting at pipe haunch areas will serve to perform that function. In addition, treating existing cracks will improve corrosion resistance of reinforcing steel in concrete pipe sections.

Grout materials selected for this project have histories of long service life in municipal environments. Specified manufacturers of grout materials have proven records of performance in tunnel/piping systems.

Soil particles consisting of sand, silt and clay have been piping through various joints into the interior. Loss of soil particles to pipe interior may cause surface sink holes, void zones, and potentially lower the bearing resistance at culvert pipe invert and springlines.

Current seals at pipe joints consists of an asphalt mastic troweled into the tongue-and-recess flanges. In many cases that asphalt mastic has fallen out via groundwater fluctuations; differential, longitudinal or transverse pipe strain; and/or gravity, among other potential environmental considerations.

This elliptical concrete pipe restoration design serves to dramatically improve resistance of soil piping through joints and further increases soil bearing resistance between springlines and invert (haunch areas). The elliptical concrete pipe restoration work shall be performed in the following sequence:

1.) Step 1, Injection of hydrophilic polyurethane grout into elliptical concrete pipe tongue and recess joints to fill voids, adhere materials together, and establish an initial plug on exterior. This procedure will occur at every elliptical concrete pipe joint as noted in the Scope of Work drawings (pages 10 to 24). See “A” series drawings as noted in Section 03 64 13 of the specifications as WP-1.

2.) Step 2, Injection of an acrylic grout through same drill holes, however extended, to create a solidified soil mass at pipe exterior. Solidified soil mass increases soil strength and impedes soil particle flow with water movement at concrete pipe joints. This procedure will occur at every elliptical concrete pipe joint as noted in the Scope of Work drawings (pages 10 to 24). The first 10 pipe sections (joints) at portals will use a glycol modified acrylic grout to provide freeze thaw resistance over time. See "B" series drawings as noted in Section 03 64 20 of the specifications as WP-2.

3.) Step 3, involves soil solidification via permeation grouting (curtain grouting) in granular soils and fracture grouting in cohesive soils (soil stabilization) to improve soil bearing resistance between invert and springline areas (haunch locations). This procedure will occur at every elliptical concrete pipe section joint as noted in the Scope of Work drawings (pages 10 to 24). See "C" series drawings as noted in Section 03 61 10 of the specifications as SS-3.

4.) Steps 4, 5, and 6, could be interchanged without concern of sequence.

5.) Step 4 is treatment procedures for cracks equal to or less than 0.020 inches (0.02" = 20 mils). Crystalline treatment of cracks accelerates autogenous healing and reduces ability of fine silt and clay particle migration through said cracks. This procedure will occur at every elliptical concrete pipe section where noted on the Scope of Work drawings (pages 10 to 24). See "D" series drawings as noted in Section 07 16 16 of the specifications as WP-4.

6.) Step 5 is treatment procedures for cracks less than 0.040 inches (0.040" = 40 mils) and greater than 0.020 inches (0.020" = 20 mils). Polyacrylate grout injection via interception grouting of cracks seals against water leakage and reduces ability of fine sand, silt and clay particle migration through said cracks. This procedure will occur at every elliptical concrete pipe section where noted on the Scope of Work drawings (pages 10 to 24). See "E" series drawings as noted in Section 03 64 10 of the specifications as WP-5.

7.) Step 6 is treatment procedures for cracks less than 0.120 inches (0.120" = 120 mils) equal to and greater than 0.040 inches (0.040" = 40 mils). Epoxy grout injection via surface mounting techniques seals against water leakage and reduces ability of medium sand, silt and clay particle migration through said cracks. This procedure will occur at every elliptical concrete pipe section where noted on the Scope of Work drawings (pages 10 to 24). See "F" series drawings as noted in Section 03 64 23 of the specifications as WP-6.

8.) Step 7 is treatment procedures for joints which exceed 1.50 inches in width equal or exceed one and one-half inches (1.5") in width at any location along the pipe joint. The possibility of interior joint seals falling out from elliptical concrete pipe joints over time is higher in these wider situations. This procedure will occur at every elliptical concrete pipe joint exceeding 1.50 inches and noted on Scope of Work drawings (pages 10 to 24). See "G" series drawings as noted in Section 07 13 56 of the specifications as WP-7.

9.) Step 8 is general filling of lift holes, spalls and chips at most elliptical concrete pipe sections with cementitious mortar equal in strength to the original concrete pipe (pages 10 to 24).

For any additional items of explanation or questions please contact me.

Respectfully submitted.



Brent Anderson, PE
Wis. # 23802 - 6

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4. Section 07 16 16 - Crystalline Waterproofing Pages 1 thru 8
5. Section 03 64 10 - Polyacrylate Grout Crack Injection Pages 1 thru 17
6. Section 03 64 23 - Epoxy Resin Crack Injection Pages 1 thru 15
7. Section 07 13 56 - Thermoplastic Sheet Strip Seals Pages 1 thru 7

I hereby certify that the plan, specifications or report was prepared by me or under my direct supervision and that I am a duly registered Professional Engineer under the laws of the State of Wisconsin.

Date: 11/22/2019 Registration No: 23802-6

By: Brent Anderson

Section 03 61 10 -- Ultra-Fine Cement, Soil Stabilization

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes micro/ultra-fine cementitious grout injection through concrete culvert pipe haunch areas to fill voids, densify/compact, and partially solidify soil particles on pipe perimeter.

B. Work of this section is designated on drawings as soil solidification/stabilization, SS-3 and is shown and itemized in Scope-of-Work section on Construction Documents.

C. Related Sections: Other specification sections, which directly relate to Work of this Section and include, but are not limited to, the following:
1. Section 03 64 13 Polyurethane Grout, Crack-Joint Injection, WP-1
2. Section 03 64 20 Acrylamide Grout Joint Injection, Soil Solidification, WP- 2
3. Section 03 61 10 Ultra-fine Cement, Soil Stabilization, SS-3
4. Section 07 16 16 Crystalline Waterproofing, WP-4
5. Section 03 64 10 Polyacrylate Grout Crack Injection, WP-5
6. Section 03 64 23 Epoxy Resin Crack Injection, WP-6
7. Section 07 13 56 Thermoplastic Sheet Strip Seals, WP-7

D. Contractor shall be responsible for reviewing site conditions to verify quantities.

E. Contractor shall be responsible for magnitude (depth and width), scope (length) of permeation grouting control as schematically shown and outlined on the contract documents.

F. Contractor shall follow prescriptive requirements of this specification; however, Contractor may modify as necessary the procedures, products, and installation to achieve soil improvement, and water control through leaking concrete culvert pipes if approved via shop drawings.

1.2 SECTION INCLUDES

A. Cementitious injection grouting for solidification of soils from springline to invert on each side of elliptical tunnel cross-section.
1. Examination.
2. Preparation and Layout.
3. Drilling Injection Ports.
4. Setting Injection Ports.
5. Injection Grouting Operations.
6. Solidification Grouting Verification
7. Remediation Grouting.
8. Clean-up and Demobilization.

1.3 REFERENCES

A. Reference Standards: Latest edition as of Specification date.
   1. American Society for Testing and Materials (ASTM) - ASTM International:
      a. ASTM C507 Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
      b. ASTM C1840 Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain and Storm Sewer Pipe.
      c. ASTM C42/C42M: Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
      d. ASTM C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
      e. ASTM D2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
      f. ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
      g. ASTM A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
      h. ASTM C33, Standard Specification for Concrete Aggregate
      i. ASTM 050, Standard Specification for Portland Cement.
      j. ASTM C940, Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory.
      k. ASTM D1785, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
      l. ASTM D2241, Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
      m. ASTM F2304 Standard Practice for Rehabilitation of Sewers using Chemical Grouting (latest revision).
      n. ASTM F2454 Standard Practice for Sealing Lateral Connections and lines from the mainline Sewer Systems by Lateral Packer Method, Using Chemical Grouting (latest revision).
      o. ASTM 091, Standard Test Methods for Time of Setting of Hydraulic Cement by VI cat Needle.

B. State of Wisconsin Department of Transportation (WisDot):
   1. Standard Specification for Construction.
   2. Standard Specifications for Construction of storm sewer and drainage structures.

C. Department of Labor, Occupational Safety and Health Administration (OSHA):
   1. Occupational Safety and Health Standards – Excavations, Final Rule – 29 CFR, Part 1926

D. American National Standards Institute (ANSI):
   1. Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD), Z535.1 Safety Color Code
   2. ANSI/NSF 61, Drinking Water System Components – Health Effects.

E. American Public Works Association (APWA):

1. Uniform Color Code for Temporary Marking of Underground Utility Locations.

F. Other Applicable Standards:
1. API RP 13B-1, Recommended Practice for Field Testing Water-based Drilling Fluids.
2. National Association of Sewer Service Companies (NASSCO) prepared Pipeline Assessment and Certification Program (PACP), TV inspection form and sewer condition codes.

1.4 ABBREVIATIONS:

A. Commonly used abbreviations used in this specification are as follows:
1. OR – Owners Representative
2. CO – Contracting Officer
3. COR -- Contracting Officer's Representative.
4. COTR – Contracting Officer's Technical Representative
5. M/E/P – Mechanical Electrical Plumbing
6. SPI – Safety Performance Index
7. EDR – Engineering Design Representative
8. SDS – Safety Data Sheet
9. HEPA -- High Efficiency Particulate Air
10. mm – millimeters (40 mils = 1 mm)
11. mil – millage, 1/1,000 inch = 0.001"
12. QA – Quality Assurance
13. QC – Quality Control
14. WP –Waterproofing
15. SS – Soil Solidification/Stabilization

1.5 DEFINITIONS

A. Quality Control: A system for verifying and maintaining a desired level of quality in an existing product or service by careful planning, use of proper equipment, continued inspection, and corrective action as required.

B. Quality Assurance: A systematic monitoring and evaluation program for various aspects of a project, service, or facility to ensure that standards of quality are being met.

C. Chemical Grout: A low viscosity, reactive, polymer resin which penetrates soil particle pore space under a gauge pressure; also commonly referred to as grout, injection resin or gel grout.

D. Grout(s): Generic term describing various liquid/gel/paste injection materials-including Portland cement (with or without fine aggregate), micro-fine and ultra-fine cement, and/or bentonite blends, reactive polymer(s) such as urethane (hydrophobic/hydrophilic), silicate, epoxy, acrylamide, methacrylate and polyacrylate resins, solvent based rubber gels, and hot/cold asphalt fluids and/or emulsions.

E. Solidification Grouting: Process of injecting chemical grout under pressure filling

the pore space of soil particles in a specified zone of influence; also referred to as permeation grouting, soil solidification or soil stabilization, chemical grouting, grouting, and/or pressure injection.

1. Grout Curtain: A physical element having volume, -- length, width, and depth of modified or solidified/densified soil having low permeability qualities and increased strength.

F. Sectioning: Grout curtain in soil strata arranged to seal off individual structural sections. Used in connection with “charge” and “re-charge” grouting pipes to create a grout curtain system, which promotes watertightness control and facilitates leakage remediation.

G. Charge and Re-Charge Pipes: Drilled holes for permeation grouting process. Charge holes are pressurized with grout and re-charge holes allow pressure relief and monitoring of grout flow path; also referred to as “inlet/outlet” ports.

H. Control and Grouting Pipes: Pipes typically installed near water barrier intersections to control watertightness of individual membrane sections. If leakage should occur, the pipes are used for remedial grouting specifically located at each connection within the structural element; also referred to as “inlet/outlet” ports.

I. Sleeve Port(s): Injection pipe(s) of various diameters with incremental openings (typically 15 inches on center) along its length, covered with a rubber gasket; also called tube-a-manchette (TAM).

J. Manchette tube:

1. Tube-A-Manchette (TAM) or commonly referred to as Injection pipe(s) of various diameters with incremental openings along its length and covered with a rubber gasket; also called a sleeve port.
2. Mild or stainless-steel tube (various diameters) with or without perforations.

K. Packer(s): A mechanical device, also referred to as a manchette or port, commonly placed onto manchettes and/or drilled holes in soil or concrete, which grout is pumped into, and forced through; also referred to as injection port. Devices shall be chemical resistant HDPE (high density polyethylene), leather or Teflon gaskets, and stainless-steel frame.

L. Slide Packer(s): A mechanical device placed in manchettes with sectionalized inflatable or friction gaskets at each end to distribute pressurized grout to incremental location(s) within the manchette or sleeve port.

M. Injection Head: Mechanical device consisting of a mixing chamber for one or more parts of resin with quick-connects, an on/off switch capability, recirculation, pressure monitoring, and a cleanout; often called a “L”, “F” or “E”-Assembly”.

N. Top-down Grouting: Technique whereby grout curtain is established near ground surface and solidified zone proceeds downward.

O. Bottom-up Grouting: Technique whereby grout curtain is established at bottom of

manchette and grout zone proceeds upward.

P. Grouting Installation Form: Form provided by Contractor, documenting the location and amount of grout at each manchette location.

Q. Fracture Grouting: Pressure injection process whereby some permeation and fracking occurs in soil mass that hardens and compacts cohesive soil to some degree.

R. Remediation Grouting: Additional grouting, as proposed by Contractor and/or directed by COTR, to supplement specified injection grouting program if voids, low solidification density, inadequate permeation, or similar irregularities are identified in the grout curtain during solidification verification.

S. Primary Holes: The first set of drill holes to be injected within the grout zone.

T. Secondary Holes: The second set of drill holes injected within the grout zone. Secondary Holes are typically drilled midway between the Primary Holes.

U. Refusal: Specifications typically dictate injection rate (volume per minute), maximum allowable injection pressure (psig), and a time duration for these qualifying items. The point at which grouting is stopped on a grout hole is defined as “Refusal”. A grout injection rate of 1/4 gallon grout per minute or less, as measured each minute for 5 consecutive minutes at 100 percent of the required grouting pressure and constant grout consistency is considered refusal for this project.

V. Split Spacing Method: The procedure of drilling and grouting an additional grout hole midway between two previously drilled and grouted holes.

W. Stage: A partial grouted zone or complete depth of grouted soil in either horizontal or vertical format within the soil mass.

U. Standpipe: A length of pipe that is grouted into the collar of the probe / grout hole and used to control water inflow and contain grout in the hole.

Y. Tertiary Holes: A third set of drilled holes for grouting in the grout zone. Tertiary Holes are placed between Primary and Secondary Holes.

Z. Test Holes: Holes drilled roughly five feet from perimeter grout zone after the grouting has been completed to determine effectiveness of the grouting performed through this area.

1.6 SUBMITTALS

A. Shop Drawings: Provide project customized plan, sections and associated details showing the following:
   1. Work scope plan,
   2. Manchette locations,
   3. Depth, spacing, and pattern of manchettes,
   4. Details at terminations; interface with existing pipe materials,

5. Sealing of ports at tunnel surface,

6. Volumes of grout expected to be pumped per manchette based on the following items noted in soil investigation and geotechnical report:
   a. Soil strata conditions,
   b. Water table elevations, and
   c. Density and gradations.
7. Proposed means and methods for Remediation Grouting, if required.

B. Product Data: Injection grout material manufacturer's literature (catalogue cuts) Including:
1. written instructions for evaluating,
2. preparation,
3. treating soil,
4. tested physical and performance properties, and
5. injection instructions.

C. Additional technical data including:
1. Include temperature ranges for storage and application of materials, and special warm/cold-weather application requirements or limitations.
2. Include recommended Site protection measures.
3. Include material Safety Data Sheets (SDS) for information only.
4. Name and contact information for injection-material manufacturer's Technical Representative that will attend the Pre-installation Meeting and inspect tunnel/culvert pipe work from time-to-time.

D. Certificates:
1. Signed by injection-material manufacturer, certifying that products furnished comply with requirements and are recommended by manufacturer for uses indicated.
2. Signed by injection-material manufacturer, certifying that company and individuals performing work is approved to install its products.

E. Injection Installer/Subcontractor Qualifications: Provide documentation confirming that Specialty Contractor identified will be performing injection grouting work and his/her qualifications.

F. Installer/Subcontractor's and/or Manufacturer's field reports. Provide sample of field reports for review and approval of Owner.

G. Samples:
1. Reacted Chemical Grout in small plastic bottle or bags; and
2. 24-inch-long manchette of proposed diameter for use.

H. Chemical Grouting protection plan/narrative: Describe the intended procedures to prevent damage during construction operations. The following items shall be addressed:
1. Storage set up of equipment,
2. Storm water control and management,
3. Handling of drilling fluids if any, and
4. Testing to ensure continuous and monolithic grout curtain.

1.7 QUALITY ASSURANCE REQUIREMENTS

A. Grouting contractor/Installer shall be certified and/or an approved applicator of the manufacturer's prior to submitting proposal on this project.

B. Pre-installation Meeting:
   1. Conduct meeting at Site.
   2. Review requirements for injection Work, including:
      a. Safety protocol and tradesmen training,
      b. Construction schedule,
      c. Storm water control in elliptical concrete culvert pipe during Work operations if snow melt or rain events suddenly occur,
      d. Availability of materials, Injection Installer/Subcontractor's personnel, equipment, and facilities needed to make progress and avoid delays,
      e. Site use, access, staging and set-up location limitations,
      f. Cracks, pipe joints and haunch areas to be injected, and condition of other construction that will affect injection Work,
      g. Surface preparation and substrate condition and pretreatment,
      h. Injection procedures,
      i. Testing and inspection requirements,
      j. Site protection measures, and
      k. Governing regulations.
   3. Contractor's Project Manager and Field Superintendent, injection-material manufacturer's Technical Representative, injection subcontractor's Field Superintendent, COTR, and Owner's Grouting Consultant shall attend.

1.8 WEATHER LIMITATIONS

A. Environmental Limitations: Install injection material when existing and forecast weather conditions permit material to be installed and cured according to injection-material manufacturer's written instructions and requirements.
   1. Do not install when air and substrate temperatures or humidity are outside limits permitted by injection-material manufacturer.
   2. Provide enclosures to protect work against freezing temperatures, rain, and over exposure to UV light.
   3. Coordinate work with conditions of snow and/or ice melt, rain/sleet events or similar weather -- to ensure storm water pipe flows do not damage work and create safety issues.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials according to manufacturer's recommendations and in such manner as to prevent damage to materials and existing structure.

B. Deliver materials to Site in original containers with seals unbroken, labeled with manufacturer's name; product brand name and type; date of manufacture; lot number; SPI hazardous rating and appropriate warnings for handling; and directions for storing and mixing.

C. Keep materials dry and do not allow materials to be exposed to moisture during transportation, storage, handling and installation. Reject and remove from Site new materials which exhibit evidence of moisture during application or have been exposed to moisture or other deleterious materials.

D. Store materials in original, undamaged containers in clean, dry, protected location on raised platforms with weather-protective coverings, within temperature range required by injection-material manufacturer.

E. Limit stored materials on structures to safe loading capacity of structure at time materials are stored, and to avoid permanent structural deflection(s).

F. Conspicuously mark damaged or opened containers with contaminated materials, and remove from Site as soon as possible. Dispose materials per governmental regulations.

G. Remove and replace materials that cannot be installed within stated shelf life or obtain letter from manufacturer that shelf life can be extended.

1.10 PROJECT CONDITIONS

A. Verify existing dimensions and utilities prior to start of injection work. Notify COTR, of conditions found to be different than those indicated in the contract documents or any items that may adversely affect the Work.

B. Exercise care to avoid injection or otherwise damaging embedded items. Remove, replace, or otherwise remedy damage to embedded items at no cost to Owner or Authority.

C. If unusual or concealed conditions are discovered, stop work, and immediately notify COTR in writing.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Source Limitations: Obtain injection materials through single manufacturer as much as possible, and/or from sources approved by manufacturer of injection material(s). Basis for Design is:
Avanti International Inc.
822 Bay Star Blvd.
Webster, TX 77598
Phone 281.486.5600
Fax 281.486.7300

B. Cementitious Grout:
1. Ultrafine VX (avg. 3 microns), by Avanti International, or
2. Ultrafine cement shall be Super Fine, as manufactured by:
Nittetsu and distributed by Surecrete Inc.,
155 NE 100th Street,

Suite 300, Seattle, WA 98125, or equal.

3. The addition of catalysts, activators, inhibitors, buffers, viscosity modifiers, fluidizers, soluble additives, and other substances to change the nature of grouting materials shall be fully compatible with grouting materials and with groundwater discharge permit requirements. Tests to demonstrate compatibility shall be conducted by Contractor well in advance of their planned use. Forward test results to District or Owner within 60 days after receiving the Notice to Proceed. Additives shall be approved for use by the District or Owner.
4. Water for grout mixing shall be fresh, clean, and free from injurious amounts of sewage, oil, acid, alkali, salts, or organic matter.

C. Superplasticizer: USG Super (approx. 7 oz. per 44 lb. bag) or approved equal.

D. Auxiliary Materials:
   1. Epoxy gel: Use 1 of following or approved equal:
      a. AV-502 manufactured by Avanti.
      b. SCB Concresive 1446 manufactured by BASF Construction Chemicals, LLC.
      c. Sikadur 31, Hi-Mod Gel manufactured by Sika Corporation.
   2. Hydraulic cement: Use 1 of following or approved equal:
      a. Waterplug manufactured by BASF Construction Chemicals, LLC.
      b. SikaPlug Fast-Setting Water Stop manufactured by Sika Corporation.
   3. Plaster-of-Paris or equal for securing and anchoring manchettes.
   4. Granular bentonite or equal for securing and positioning manchettes.
   5. Manchettes and/or Sleeve Ports:
      a. PVC, schedule 40 tube or pipe, incremental openings with rubber gaskets at 15 inches on-center by Avanti International or equal.
   6. Oakum:
      a. As recommended by the Grout Manufacturer .
   7. Grouting Equipment and Accessories:
      a. All grouting equipment used shall be of a type, capacity, and condition suitable for doing the Work. The equipment and its powering and layout thereof shall meet all applicable requirements of federal, state, and local laws and regulations, and is subject to approval by the District or Owner.
      b. Equipment used for mixing and injecting grout shall be designed for grouting service, shall be maintained in satisfactory operating condition at all times, and shall be capable of satisfactorily mixing and agitating the grout and injecting it into grout holes at an essentially uniform flow rate under constant pressure. It is anticipated that, where possible, two or more holes will be pumped simultaneously using two or more pumps.
      c. The minimum grouting equipment furnished shall include, but is not limited to, the following:
         1) A cement grout mixer shall be high shear colloidal type, capable of providing a homogenized mix with an impeller speed of not less than 1500 rpm or equal.
         2) Equip the mixer with a suitable water measuring

device calibrated to read in cubic feet and tenths and so designed that, after each delivery, the instrument can be conveniently reset to zero. Provide means for accurately measuring the other grout ingredients at the mixer.

3) A mechanically driven grout agitator tank, capable of effectively stirring grout having a water-cement ratio ranging from 0.6:1 to 3:1 measured by weight and holding in suspension all solid matter contained in the grout. The outlet from this tank shall not be less than 2 inches in diameter. Place a 40 mesh-per-inch screen between the mixer discharge and holding tanks to trap any oversize particles.

d. High Shear Colloidal Mixer with agitation tank by Chem-Grout (C-630) or equal.

e. Roto-Stator grout pump (P-25) by C. J. Spray or equal with variable speed control and reverse/forward switch.

1) A cementitious grout pump capable of delivering not less than 10 gpm of grout at a pressure of 300 psi is to be used at the grout hole collar. The grout pump shall be either rotor-stator, progressive cavity type, or positive displacement grout pumps, such as duplex double-acting pumps of the long-stroke type, with large valve openings, equipped with removable valve seats, or equal. In addition to the two pumps being used in the headings, keep on site a backup pump of the same capacity and arrangement, and in good working condition.

2) Such valves, pressure gauges, pressure hose, small tools, and accessories as may be necessary to provide a continuous supply of grout and accurate pressure control. The inside diameter of the delivery, return lines and grout nipples, shall be not less than 1-inch. All hoses, valves, and fittings, etc., must be rated for a working pressure exceeding 300 psig.

f. Stainless Steel, 1-to-1 ratio, dual piston pump, with pressure control gauges.

g. Stainless steel diaphragm pumps for supplying grout to pump from mixing barrows.

h. Stainless steel “F”-Assembly with check-valves and ball valve control.

i. Chemical resistant, insulated injection hose lines for work in cold weather.

j. Stainless steel/HDPE Slide Packers, air-inflatable, or friction gaskets.

k. HDPE and stainless-steel mixing barrows and paddles.

l. Stainless steel packers with needle extensions for localized grout curtain leakage remediation during excavation.

m. Water and/or liquid control meters for grout volume monitoring. Flow meters shall be capable of accurately registering flow rates to 0.2 gpm.

PART 3 - EXECUTION

3.1 GROUTING PHASES AND GENERAL WORK SCOPE

A. Perform injection grouting operations at manchette drill hole locations shown on the contract documents. The grout curtain zone at pipe haunch areas shall include granular soils above and below the groundwater table, and further to improve soil support strength and minimize soil induced settlement of elliptical pipe culvert sections.

B. First Pass: Injection grout all manchette locations. Label manchettes in the field, record locations on a drawing, the date, quantities of grout injected at each manchette, and the grout batch number on an Xcel spreadsheet.

C. Second Pass: In locations identified by soil report where more than 20 percent of soil passes the #200 sieve, repeat injection grouting at all manchette locations the following day (fracture grouting). Record the date, quantities of grout injected at each manchette, and the grout batch number on an Xcel spreadsheet.

D. Remediation Grouting: If voids are identified in the grout curtain during Solidification Grouting Verification, Contractor shall perform Remediation Grouting in accordance with approved shop drawings as directed by the COTR.

3.2 EXAMINATION

A. The injection subcontractor's Field Superintendent and injection-material manufacturer's Technical Representative shall:
   1. Ensure that work done by other trades is complete and ready for injection grouting.
   2. Examine existing substrates and site conditions to confirm compliance with grouting requirements and approved shop drawings.
   3. Notify COTR in writing of substrates or conditions that may adversely affect installation or performance of injection grouting and recommend corrections.

B. Do not proceed with injection work until adverse conditions have been corrected and reviewed by COTR and Grouting Consultant.

C. Commencing injection grouting work constitutes acceptance of work surfaces and conditions

3.3 PROTECTION

A. Protect existing surfaces from work in progress from mechanical damage due to drilling operations, scaffolding, excessive water flow, and/or methods of work and other equipment.

B. Limit access to work areas.

C. Exercise care to avoid injection or otherwise damaging embedded items. Remove and replace or otherwise remedy damage to embedded items, at no cost to the Owner / Authority.

3.4 PRESSURE INJECTION EQUIPMENT

A. Injection equipment shall be capable of pumping injection material under pressure through injection manchettes and/or ports; equipment shall be approved by injection-material manufacturer.

3.5 PREPARATION FOR SOLIDIFICATION GROUTING

A. Inspect surfaces, mark drill hole locations, and areas to be injected from the drawings.

B. Use GPR or micro-cover meter to locate steel on interior tunnel surfaces. The drawings indicate one-inch concrete cover on steel reinforcing. Steel reinforcement spacing and intensity varies at crown, springline, and invert. Three different structural reinforcement patterns are used on the project.

C. Drill holes with hammer or core drill for manchettes/packers/ports in accordance with approved shop drawings.

D. Install sleeve ports/manchettes/packers to achieve spacing patterns shown on the contract drawings.
   1. Drill holes for injection ports or packers at 90-degree angle to curved pipe surface.
   2. Alternate manchette placement from side to side along length of curtain.
   3. Insert manchettes into drilled holes in such manner that cave-ins do not occur.

3.6 MANCHETTE GROUTING

A. Perform grouting in presence of injection-material manufacturer’s Technical Representative. The Technical Representative shall provide documentation confirming that grouting was installed in accordance with requirements or an explanation of why it was not.

B. Maintain conditions and injection material at adequate temperature for suitable Time so that injection material will completely fill the manchette and will achieve full cure.

C. Using the lowest possible pressure to achieve desired result, continuously inject material into manchettes, as recommended by injection-material manufacturer.
   1. Use cementitious grout injection pressure of (15 to 25) pounds per square inch, depending on soil cover depth, manchette spacing, width, depth of grouting column, and condition(s) of soil.
   2. Start injection at lowest packer elevation (bottom up grouting) and continue until injection material reaches the pre-calculated volumes.
   3. Continue to pump cementitious grout into manchette until refusal is met or the designed material quantity is established. Refusal is defined in “Definition” section of this specification.
   4. Remove injection nozzle or head from packer immediately after injection material reaches the pre-calculated volumes.

5. Continue injection process bottom-up from manchette to manchette, monitoring grout volume per manchette.
6. Take care to keep equipment and grout lines clean during grouting operations. Flush out all equipment and grout lines after grouting each stage. Properly dispose of all waste and contaminated water in accordance with the Contract Documents and governmental permit requirements.

3.7 CLEANING

A. Protect existing tunnel surface finish(s) from grout stains where required.

B. Under no circumstances shall any drilled grout or test holes in elliptical concrete culvert pipe tunnel sections be left unsealed with cementitious mortar fill exceeding 6,000 psi compressive strength.

C. Clean surfaces of excess grout, and injection ports or packers.
1. Allow injection material enough time to cure before performing cleanup.
2. Clean surfaces by grinding or other means.
3. Patch holes at injection ports.

PART 4 - CONTRACTOR'S QUALIFICATIONS AND QA/QC REQUIREMENTS

4.1 GENERAL

A. Pre-Installation Meeting: Prior to start of Work and at Contractor's direction, meet at Project site to review methods and sequence of grouting installation, special details and conditions, standard of workmanship, testing and quality control requirements, job organization and other pertinent topics related to the Work. The meeting shall include the COTR, Contractor/Installer's quality assurance technician, Project Superintendent, Contractor's Subcontractor's Superintendent, Grout material manufacturer's representative, inspection and testing services personnel, and any other subcontractors whose work requires coordination.

B. Inspection:
1. Manufacturer's representative to inspect on-going work on a bi-weekly basis and upon completion of each type of grouting, further provide a written report that application complies manufacturer's instructions at the end of each inspection.

C. Product:
1. Supply and install only products specifically designed and manufactured for this type of construction.
2. Select manufacturers of accessory products who are regularly engaged in the production of similar materials for underground structures.

D. Supervision and Training of Personnel:
1. Execute all installation and testing under the direct supervision of an individual with a minimum five (5)-years-experience in installation of grouting systems for underground structures using similar materials.

2. The installer must have a minimum of five (5) years of experience at installation of grouting/injection materials in underground installations.
3. The proficiency of each technician shall be demonstrated in the field for approval by the Contracting Officer's Technical Representative (COTR).
4. The grouting system(s) shall be applied only by an approved contractor authorized by the Manufacturer prior to bid.
5. All work shall be completed by trained and authorized personnel.
6. Installation of grouting/injection system(s) shall be the responsibility of the Grouting Applicator to ensure undivided responsibility.
7. Upon request, the Applicator must submit a list of jobs performed by his employees and supervisors similar to the proposed system being bid.

E. Manufacturer's Performance:
1. Shall have documented experience of more than 10-years supplying grout materials for stormwater piping systems.
2. The grouting/injection products are to made by a nationally-recognized manufacturer specializing in water control systems; have been used successfully on projects similar to this; and are appropriate for the substrate, groundwater, hydrostatic pressure, and soil/rock contamination conditions that may be expected in this Contract.

F. Installation Contractor:
1. Installation contractor of grouting materials shall be certified and/or be approved by the manufacturer in writing prior to bid submission.

4.2 FIELD QUALITY CONTROL

A. Installer's quality assurance technician shall be present during grouting work.

B. Provide:
1. Access to Work.
2. Materials for sampling.
3. Site facilities for sampling, testing, and storage of materials.
4. Incidental labor.

C. Sample each batch of material to be injected to determine reaction times: Obtain 1 sample of the injection material prior to beginning injection Work each day, representing first 50 feet of injection, and 1 sample for every 100 feet of injection thereafter. Provide the following:
1. Allow samples to cure.
2. Do not begin injection Work each day until initial sample has satisfactorily cured from the following day.
3. Label samples:
   a. with injection date, and
   b. location of injected manchette represented by sample.
4. Retain samples in a safe location on site.

D. Monitor and Report:
1. Ambient temperatures,
2. Grout consumption per manchette,

3. Equipment pressures, and
4. Material ratios.

4.3 TESTING AND INSPECTION

A. Soil Stabilization/Solidification Grouting Verification
1. Contractor shall install one boring in grout curtain zone per pipe section or/and at locations determined by the COTR to confirm the extent and effectiveness of the grouting program.
2. Contractor shall collect samples from the borings. Samples shall be examined in the field by Owner's Grouting Consultant to evaluate the effectiveness of the grouting procedure. Two samples may be collected from each boring for laboratory analysis of unconfined compression testing if sampling is suspicious of not meeting requirements.
3. Based on the results of field examination and laboratory analyses, Owner's Grouting Consultant will determine if the solidification grouting program meets Owner's needs or if Remediation Grouting is necessary. The COTR will direct the Contractor accordingly.

B. Field Quality Control
1. An inspection agency may be engaged by the Authority to inspect work specified herein. The presence of the Inspection Agency is for the Authority's own purposes and any information or assistance furnished by this Inspection Agency shall not relieve the Contractor of the responsibility for the Work.

C. Contractor's Responsibility:
1. Attend a pre-installation examination and acceptance of substrate and surface preparation for each stage. Issue report.
2. Be present at initial start-up for each process. Confirm application rates and techniques. Issue report.
3. Issue summary report at completion of installation indicating Manufacturer's acceptance of installed system.
4. Provide any Inspection Agency personnel with safe access to the Work.
5. Notify the Inspection Agency whenever work is to be done, with enough time to arrange inspection, (3-day notice).
6. Cooperate with any inspection and testing service that may be engaged by the Authority to perform on-site inspection of the membrane waterproofing work. Comply with the inspector's request in connection with specific test samples and provide any additional testing that may be requested in order to confirm that the work complies with the requirements.
7. Discontinue any practice immediately when notified, which, in the Inspection Agency's opinion, is not in accordance with the Specifications or will act to the detriment of the system. The Inspection Agency will notify the Authority, the COTR, the Contractor and the manufacturer immediately of all violations. Any work affected by improper practice will be subject to complete replacement.
8. Give written notice to Inspection Agency stating that the installation has been completed in accordance with the Contract Documents and requesting a final inspection to be conducted

4.4 INSPECTION AND TESTING

A. The inspection company must be notified three (3) days in advance of any work to be performed on-site.

B. Contractor shall require Representative of Manufacturer of grouting material to provide field instruction and supervision of grout installation at start of Work of this Section and, while work is occurring. Representative shall make biweekly site inspections and send reports to COTR.

C. Contractor shall require the Manufacturer's Representative to ensure Subcontractor's workmen are fully instructed and trained in handling and application of all the materials and shall see that materials are correctly installed.

D. Upon completion of the installation, Contractor shall submit to COTR written certification that the Representative of the Manufacturer of the fluid-applied membrane waterproofing material has supervised the Work of this Section and that all materials were correctly installed.

4.5 MOCK-UP TESTING FOR CEMENTITIOUS GROUTING

A. Mock-up Test Section:
1. Test two (2) pipe sections (approximately 14 lineal feet) as described below before grouting remainder of elliptical concrete culvert pipe.
2. Test section to verify if bedding conditions meets a Type II or Type III Condition per the American Concrete Pipe Association, design manual.
3. Test holes before grouting to verify potential soil type, thickness and relative compaction of fill material.
4. Test holes after grouting to verify that grout has penetrated or fractured soil and made it more compact.
5. Test holes should verify that haunch soils are more compact than soil at the invert (6 o'clock position).
6. Tests to verify grout type, mix ratio and quantity of grout pumped to increase haunch compaction, however, note that invert area to be less compacted then haunch areas.
8. Test all 8 holes before grouting.
9. Test 6 new holes after grouting.
10. Test with static cone penetrometer to verify it adequately tests for soil resistance present.
11. Test in the presence of a Qualified Engineer.
12. Qualified Engineer to approve grouting of mock-up test section has met above requirements, before grouting remainder culvert pipes.
13. Qualified Engineer to set testing requirements for remainder of pipe to be grouted. As a minimum each pipe must have 1 test hole in the haunch and 1 test hole at the 6 o'clock floor position.

END OF SECTION 03 61 10

Section 03 64 10 -- Polyacrylate Grout, Crack Injection

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes polyacrylate grout injection through the concrete culvert pipe cracks from 21 mils to 39 mils to seal against water entry and solidify soil particles on pipe perimeter.

B. Work of this section will be designated on the drawings as WP-5 and is shown and itemized in the Scope-of-Work section on Construction Documents.

C. Related Sections: Other specification sections, which directly relate to the Work of this Section and include, but are not limited to, the following:
1. Section 03 64 13 Polyurethane Grout, Crack-Joint Injection, WP-1
2. Section 03 64 20 Acrylamide Grout Joint Injection, Soil Solidification, WP- 2
3. Section 03 61 10 Ultra-fine Cement, Soil Stabilization, SS-3
4. Section 07 16 16 Crystalline Waterproofing, WP-4
5. Section 03 64 10 Polyacrylate Grout Crack Injection, WP-5
6. Section 03 64 23 Epoxy Resin Crack Injection, WP-6
7. Section 07 13 56 Thermoplastic Sheet Strip Seals, WP-7

D. Contractor shall be responsible for reviewing site conditions to verify quantities.

E. Contractor shall be responsible for magnitude (depth and width), scope (length) of permeation grouting control as schematically shown and outlined on the contract documents.

F. Contractor shall follow prescriptive requirements of this specification; however, Contractor may modify as necessary the procedures, products, and installation to achieve water control through the leaking concrete culvert pipe if approved via shop drawings.

1.2 SECTION INCLUDES

A. Injection grouting to minimize water leakage post construction and is organized as follows:
1. Examination
2. Preparation and Layout
3. Drilling Injection Ports
4. Air-flushing drill holes
5. Water-flushing drill holes
6. Setting Injection Ports
7. Pressurized Water Testing
8. Pressurized Air Testing
9. Conditions Where Excessive Leakage Occurs
10. Injection Grouting Operations
11. Re-Drilling drill holes

12. Water-flushing drill holes
13. Mortar filling drill holes
14. Clean-up and Demobilization

1.3 REFERENCES

A. Reference Standards: Latest edition as of Specification date.
   1. American Society for Testing and Materials (ASTM) - ASTM International:
      a. ASTM C42/C42M: Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
      b. ASTM C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
      c. ASTM D420: Standard Guide for Investigating and Sampling Soil and Rock.
      d. ASTM D2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
      e. ASTM F2304 Standard Practice for Rehabilitation of Sewers using Chemical Grouting (latest revision).
      f. ASTM F2454 Standard Practice for Sealing Lateral Connections and lines from the mainline Sewer Systems by Lateral Packer Method, Using Chemical Grouting (latest revision).
      g. ASTM C507 Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
      h. ASTM C1840 Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain and Storm Sewer Pipe.

B. Department of Labor, Occupational Safety and Health Administration (OSHA), Occupational Safety and Health Standards – Excavations, Final Rule – 29 CFR, Part 1926

C. American National Standards Institute (ANSI):
   1. Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD). Z535.1 Safety Color Code

D. American Public Works Association (APWA):
   1. Uniform Color Code for Temporary Marking of Underground Utility Locations.

E. Other Applicable Standards:
   1. National Association of Sewer Service Companies (NASSCO) prepared Pipeline Assessment and Certification Program (PACP), TV inspection form and sewer condition codes.

1.4 ABBREVIATIONS:

A. Commonly used abbreviations used in this specification are as follows:
   1. OR – Owners Representative
   2. CO – Contracting Officer
   3. COR -- Contracting Officer’s Representative.
   4. COTR – Contracting Officer’s Technical Representative

5. M/E/P – Mechanical Electrical Plumbing
6. SPI – Safety Performance Index
7. EDR – Engineering Design Representative
8. SDS – Safety Data Sheet
9. HEPA – High Efficiency Particulate Air
10. mm – millimeters (40 mils = 1 mm)
11. mil – millage, 1/1,000 inch = 0.001”
12. QA – Quality Assurance
13. QC – Quality Control
14. WP – Waterproofing
15. SS – Soil Solidification/Stabilization

1.5 WATER CONTROL NOMENCLATURE

A. Specification criteria:
   1. Prescriptive based-water control criteria established by design professional’s details and specifications, or
   2. Performance based- water control ways-and-means established by contractor and reviewed by design professional.

B. Water leakage nomenclature:
   1. Crack Root-The point(s) of water ingress into a concrete element.
   2. Crack Mouth- The points of water discharge from a concrete element.
   3. Trail- A noticeable pathway/stain on concrete element surface designating continuous water flow.
   4. Ponding- The accumulation of water leakage through a concrete element.

C. Five levels of water accumulation on a concrete element can be physically described as follows:
   1. Color change (darker), when high moisture content exists at concrete element surface, (white/crystalline or efflorescence) when area has re-sealed itself via autogenous healing), not visually wet to touch, no ponding occurs;
   2. Wet to touch, surface dampness in spots, no sustained water trail present, no ponding occurs;
   3. Weeps and seepage, sustained trail of wetness, however, visual surface flow not apparent, ponding does occur;
   4. Continuous dripping, visual surface flow or water movement over Gushing concrete element, ponding occurs and leaves trail; or
   5. flow, from presence of hydrostatic back pressure, ponding leaves continuous trail of water.

D. Water Control: Water control at concrete elements serves many purpose(s):
   1. Minimizes potential of dissolved oxygen, carbon dioxide, free chlorides and various salts/contaminants from entering concrete through-wall/floor/elevated-deck cracks and joints.
   2. Helps control and potentially mitigate the following:
      a) Internal steel reinforcing bar corrosion,
      b.) Hardware corrosion of externally attached metal adjacent to wet area,

c.) Concrete carbonation,
d.) Alkali Silica Reactivity and Delayed Ettringite Formation,
e.) Surface delamination of paints, coatings, and high build flooring components,
f.) Nutrient Source for mold, algae, and bacterial growth organisms,
g.) Interior surface stains, efflorescence, salt, and carbonate buildups (stalactites/stalagmites),
h.) Ice formation (icicles) in unheated enclosures,
I.) Slippery surfaces,
j.) Electrical short circuits, and/or shocks,
k.) Conductor for stray current corrosion,
l.) Potential soil particle loss, and
m.) Costly cleanup when hazardous contaminants (radioactive or poisonous hydrocarbons) enter and accumulate.

E. Structural Parameters: Three important considerations for successful grouting without damaging the structural concrete elements are as follows:
1. Pressures more than 600 psig can cause tensile damage (fracking) to existing concrete elements;
2. Crack width is inversely proportional to pump gauge pressure; and
3. Crack width is proportional to grout viscosity required for proper penetration.

F. Water leakage flow paths:
1. Through-element primary and secondary cracks/joints;
2. Voids and shadows along horizontal or vertical steel reinforcing bar;
3. Unbonded surfaces between concrete and mechanical, electrical, plumbing, penetrations, inserts, or sleeves and dewatering hardware;
4 Poorly consolidated and/or honeycombs within concrete element at cold and/or construction joints;
5. Porous foreign objects/debris and/or soil deposits trapped within the concrete element during forming/placement construction and subsequent placement;
6. Through element braided copper wire ground cables;
7. Form-tie brackets, anchors, wire, or any such temporary or permanent structural inserts.

G. Crack Nomenclature and Width Definitions:
1. Cracks and joints as fine as 1/1000 inch (1 mil) are subject to water leakage if hydrostatic back pressure exists. Water leakage volumes are related to hydrostatic pressure, crack/joint width, and internal friction at crack/joint sidewalls. Cracks and joints are defined as follows:
a. ultra-fine crack/joint (01 to 05) mils (0.025 to 0.127) mm
b. very-fine crack/joint (06 to 10) mils (0.152 to 0.254) mm
c. fine crack/joint (11 to 15) mils (0.279 to 0.381) mm
d. medium-fine crack/joint (16 to 20) mils (0.406 to 0.508) mm
e. medium crack/joint (21 to 40) mils (0.533 to 1.016) mm
f. medium-wide crack/joint (41 to 60) mils (1.041 to 1.524) mm
g. wide crack/joint (61 to 120) mils (1.549 to 3.048) mm

1.6 DEFINITIONS

A. QA – Quality Assurance: A system for verifying and maintaining a desired level of quality in an existing product or service by careful planning, use of proper equipment, continued inspection, and corrective action as required.

B. QC – Quality Control: A systematic monitoring and evaluation program for various aspects of a project, service, or facility to ensure that standards of quality are being met.

C. Grout(s): Generic term describing various - structural and/or non-structural, cementitious and/or non-cementitious materials which are installed as a liquid, paste or gel/mastic; which may cure-out as a product that exhibits a high or low modulus resulting in an elastic/plastic foam, gel, or paste-like matrix. Injection or placement materials include Portland cement (Types I, II, III, IV, or V, with or without fine aggregate, neat cement as micro-fine and ultra-fine in particle size) and/or bentonite powder blends, potassium/sodium silicates, reactive polymer(s), such as urethane (hydrophobic/hydrophilic), epoxy, methyl-methacrylate, acrylamide and polyacrylate resins, solvent (hydrocarbon or water) based rubber gels, and hot/cold asphalt fluids and/or emulsions. Grout viscosity has a relationship with pumping pressure and crack width, among other parameters such as temperature, cross-sectional width of voids, gel-time, and water chemistry. Four grout designations are as follows:
   1. Low viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material when initially mixed facilitates a viscosity of (1 to 15) centipoise. Said grouts under controlled pressure penetrate ultra-fine cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.
   2. Medium viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material when initially mixed facilitates a viscosity of (50 to 100) centipoise. Said grouts under controlled pressure penetrate fine cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.
   3. High viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material when initially mixed facilitates a viscosity of (500 to1,000) centipoise. Said grouts under controlled pressure penetrate medium-wide cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.
   4. Very-high viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material or non-reactive fluid when initially mixed facilitates a viscosity of (2,000 or greater) centipoise. Said grouts under controlled pressure penetrate wide cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.

D. Interception Grouting: Process by which a crack or joint is intercepted between its mouth and root (origin), and further a chemical grout is pumped into it under gauge pressure to fill any void space left in the concrete matrix.

E. Permeation Grouting: Process of injecting chemical grout under pressure filling the pore space of soil particles in a specified zone of influence; also referred to

as soil solidification, chemical grouting, curtain grouting, and/or pressure injection.

F. Grout Curtain: A solidified soil element (of length, width, and depth) having low permeability qualities.

G. Sectioning: Grout curtain in soil strata arranged to seal off individual structural sections. Used in connection with “charge” and “re-charge” grouting pipes to create a grout curtain system, which promotes control of watertightness and facilitates leakage remediation.

H. Charge and Re-Charge Pipes: Drilled holes for permeation grouting process. Charge holes are pressurized with grout and re-charge holes allow pressure relief and monitoring of grout path; also referred to as “inlet/outlet” ports.

I. Control and Grouting Pipes: Pipes typically installed near water barrier intersections to control water-tightness of individual waterproof membrane sections. If leakage should occur, the pipes are used for remedial grouting specifically located at each connection or interruptions to concrete pours; also referred to as “inlet/outlet” ports.

J. Sleeve Port(s): Injection pipe(s) of various diameters with incremental openings (perforated pipe) along its length, covered with a rubber gasket; also called manchette tube or Tube-A-Manchette (TAM).

K. Manchette tube: Tube-A-Manchette (TAM) or commonly referred to as Injection pipe(s) of various diameters with incremental openings along its length, covered with a rubber gasket; also called a sleeve port.

L. Packer(s): A mechanical device placed into or through drilled holes in concrete elements or driven into soil, through which grout is pumped into, and forced through; also referred to as injection port, expandable packer, or wall sphere. Devices shall be chemical resistant HDPE (high density polyethylene), neoprene rubber, leather or Teflon gaskets, and stainless-steel, brass, aluminum, or carbon steel frame. Most contain a grease zerk, button head, or quick-connect for attachment to the Injection head.

M. Slide Packer(s): A mechanical device placed into plastic manchettes with sectionalized inflatable or friction gaskets (leather or Teflon) at each end to control and distribute pressurized grout to incremental location(s) within the manchette or sleeve port.

N. Injection Head or Gun: Mechanical device consisting of a mixing chamber for one or more parts of resin with quick-connects, zerk grease fitting, button head, and an on/off switch or ball-valve to control flow and capability, recirculation, pressure monitoring, and a cleanout; often called an “E” or “F”-Assembly.

O. Crystalline Waterproofing Mortar: Portland cement/silica sand mortar with reactive chemical admixture that promotes crystalline growth in the reinforced element. Reactive chemicals combine the free calcium hydroxide in concrete to crystallize and imped water flow.

P. Top-down Grouting: Injection technique whereby grout curtain is established near ground or exposed surface, once that solidifies, manchettes are drilled through the solidified zone and grouting proceeds sequentially downward.

Q. Bottom-up Grouting: Technique whereby grout curtain is established at bottom of hole and manchettes are sequentially lifted and grout zone proceeds upward.

R. Grouting Installation Form: Form provided by Contractor, documenting the location and amount of grout in each manchette location.

S. Dual and Single Component Pump(s): Operated with compressed air, electric, hydraulic oil, or mechanically operated pump with single mechanism or multi-ratio mechanisms for pumping various grout components.

1.6 SUBMITTALS

A. Shop Drawings: Provide project customized plan, sections and associated details showing the following:
   1. Work scope plan if different from contract documents.

B. Product Data: Injection grout material manufacturer's literature (catalogue cuts) Including:
   1. Written instructions for handling, mixing, and safety procedures.
   2. Technical data including tested physical and performance properties, including:
      a. Temperature ranges for storage and application of materials, and special warm/cold-weather application requirements or limitations,
      b. Include recommended Site protection measures, and
      c. Safety Data sheets.

C. Certificates:
   1. Signed by injection-material manufacturer, certifying that products furnished comply with requirements and are recommended by manufacturer for uses indicated.
   2. Signed by injection-material manufacturer, certifying that individual(s) performing work is approved to install its products.

D. Injection Installer/Subcontractor Qualifications: Evidence that Subcontractor's existing company has minimum 5 years of continuous experience in injection of specified materials; list of at least 5 representatives, successfully completed projects of similar scope and size, including:
   1. Project name.
   2. Owner's name.
   3. Owner's Representative name, address, and telephone number.
   4. Description of work.
   5. Injection materials used.
   6. Equipment used.
   7. Project supervisor.
   8. Total cost of injection work and total cost of project.
   9. Completion date.

E. Installer/Subcontractor's and/or Manufacturer's field reports.

F. Resume' of chemical grouting installation supervisor.

G. Samples: Reacted Chemical Grout in small plastic bottle.

H. Chemical Grouting protection plan/narrative: Describe the intended procedures to prevent damage during construction operations. The following items shall be addressed:
1. Storage and set up of equipment,
2. Restoration of drill holes,
3. Steel reinforcing location plan,
4. Handling of drilling fluids and waste products if any, and
5. Testing to ensure continuous and monolithic grout pattern.

1.7 QUALITY ASSURANCE REQUIREMENTS

A. Personnel identified during prequalification process shall be the personnel conducting the Work.

B. Pre-installation Meeting:
1. Conduct meeting at Site.
2. Review requirements for injection Work, including:
   a. Safety protocol and tradesmen training,
   b. Construction schedule,
   c. Availability of materials, Injection Installer/Subcontractor's personnel, equipment, and facilities needed to make progress and avoid delays.
   d. Site use, access, staging and set-up location/limitations.
   e. Cracks and joints to be injected, and condition of other construction activity that will affect injection Work.
   f. Injection procedures.
   g. Testing and inspection requirements.
   h. Site protection measures.
   i. Governing regulations.

C. Contractor's Site superintendent, injection-material manufacturer's technical representative, Injection Subcontractor's foreman, COR, COR's Representative, and Grouting Consultant, shall attend.

1.8 WEATHER LIMITATIONS

A. Environmental Limitations: Install injection material when existing and forecast weather conditions permit material to be installed and cured according to injection-material manufacturer's written instructions and warranty requirements.

B. Do not install when air and substrate temperatures are outside limits permitted by injection-material manufacturer. Provide enclosures to ensure against freezing temperatures and or over exposure to UV light, unless approved in writing by injection-material manufacturer.

C. Contractor/Grouting Installer shall be aware that un-managed water can be a safety issue.

D. Do not work in severe temperatures, moisture, and excessive humidity; these may affect the installation and performance of products during construction. Consult with Manufacturer's Representative and comply with applicable material recommendations for workmanship and handling.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials according to manufacturer's recommendations and in such manner as to prevent damage to materials and existing structure.

B. Deliver materials to Site in original containers with seals unbroken, labeled with manufacturer's name; product brand name and type; date of manufacture; lot number; SPI hazardous rating and appropriate warnings for handling; and directions for storing and mixing.

C. Keep materials dry and do not allow materials to be exposed to moisture during transportation, storage, handling and installation. Reject and remove from Site new materials which exhibit evidence of moisture reaction during application or have been exposed to abuse or other deleterious materials.

D. Store materials in original, undamaged containers in clean, dry, protected location on raised platforms with weather-protective coverings, within temperature range required by injection-material manufacturer.

E. Limit stored materials on structures to safe loading capacity of structure at time materials are stored, and to avoid permanent deck deflection.

F. Conspicuously mark damaged or opened containers with contaminated materials, and remove from Site as soon as possible. Dispose containers to legal dump site.

G. Remove and replace materials that cannot be installed within stated shelf life.

1.10 PROJECT CONDITIONS AND SAFETY PROTOCOL

A. Verify existing dimensions and any known utilities (buried drainpipes, electrical or telecom service) prior to start of injection Work. Notify COR, if conditions found to be different than those indicated in Contract Documents. Be aware of buried utilities, (drainpipes, electrical or telecom service) unknown at time of drilling.

B. If unusual or concealed conditions are discovered, stop work, and immediately notify COR in writing. Be aware of private drain line pipes and fields.

C. Provide adequate ventilation and protect adjacent building air intakes (if any) to ensure no adverse effects from grout fumes, smells or odors. Note the following:
1. Acrylic grout oxidizers give off an ammonia smell/vapor,

2. Urethane grouts give off MDI or TDI smell/vapors,
3. Carbon dioxide is released as part of polyurea/polyurethane reaction,
4. Hot asphalt can give off benzene vapors and hydrocarbon smells,
5. Bentonite and cement grouts give off silica dust when mixing with water,
6. Hydrocarbon solvents are released when used as a viscosity reducer,
7. Drilling into concrete produces silica dust, and
8. Adding ethylene glycol to air intake lines of grout pump can produce hydrocarbons in the immediate area.

D. Follow OSHA regulations during work performance, and particularly when the following occurs:
1. Trades people are working on platforms and scaffolding,
2. Heights more than four feet,
3. When using ladders,
4. When drilling into concrete and creating sparks and dust,
5. Use OSHA approved HEPA dust collection systems when drilling into concrete elements,
6. Wear goggles, face shields, or similar when high grout pressures are used, and
7. Wear proper PPE clothing and gloves when handling solvent, hot, and/or reactive chemicals.

PART 2 – MATERIALS

2.1 PRODUCTS

A. Source Limitations: Obtain injection materials through single manufacturer as much as possible, and/or from sources approved by manufacturer of injection material.

B. Approved Products and Chemical Grout Manufacturers/Suppliers:
1. Aquafin PM-3811-Flex by Aquafin, Inc., 505 Blue Ball Road, No.160, USA - Elkton, MD 21921, Phone: (410) 392-2300, Fax: (410) 392-2324
2. AV-150 by Avanti International, 822 Bay Star Blvd., Webster TX. 77598 Phone: 800-877-2570 Fax: 281-486-7300
3. Or-equal grout manufacturer. Products shown to be equal in viscosity, solids percentage in acrylic resin component, chemical composition, and performance are of consideration by Specifying Engineer. Approved equal products must be approved in writing prior to bid proposal.

C. Approved Products for plugging drill holes:
1. Aquafin Mortar IC or Aquafin-Plug-IC by Aquafin, Inc., 505 Blue Ball Road, No.160, USA - Elkton, MD 21921.

D. Auxiliary Materials:
1. Epoxy gel: Use 1 of following or approved equal:
a. AV-522 Epoxy Paste by Avanti International, 822 Bay Star Blvd., Webster TX. 77598 Phone: 800-877-2570 Fax: 281-486-7300
b. SCB Concresive 1446 manufactured by BASF Construction

Chemicals, LLC.
c. Sikadur 31, Hi-Mod Gel manufactured by Sika Corporation.

2. Crystalline Waterproofing Mortar: Use the following or approved equal:
   a. Aquafin 1C mortar
   b. Aquafin-Plug-IC
3. Hydraulic cement: Use one of following or approved equal:
   a. Aquafin-Plug-IC, manufactured by Aquafin Inc.
   b. Water plug manufactured by BASF Construction Chemicals, LLC. SikaPlug Fast-Setting Water Stop manufactured by Sika Corporation.
4. Oakum:
   a. As recommended by the Grout Manufacturer.
5. Grouting Equipment and Accessories:
   a. Stainless Steel, 1-to-1 ratio, dual piston pump, with pressure control gauges for hydrophilic urethane, acrylamide and polyacrylate grouts.
   b. Stainless steel diaphragm pumps for supplying grout to pump from mixing barrows if necessary.
   c. Stainless steel “E” or “F”-Assembly with check and ball valves.
   d. Chemical resistant, insulated injection hose lines for work in cold or hot weather.
   e. Grease zerk or button head expandable packers to match drill hole size.
   f. HDPE and/or stainless-steel mixing barrows and paddles.
   g. Stainless steel packers with needle extensions where required for localized grout conditions.
   h. Water and/or liquid control meters for grout volume monitoring.

PART 3 - EXECUTION

3.1 GROUTING PHASES AND GENERAL WORK SCOPE

A. There are two scopes of work which polyurethane grout is proposed for use:
   1. Elliptical pipe joint grouting at asphalt mastic seals, and
   2. At cracks in elliptical concrete sections which range from (40-to-120) mils.

B. Perform injection grouting operations at locations shown on contract documents. Inject cracks and joints in elliptical, reinforced, concrete pipe that exhibits water leakage.

C. First Pass: Perform injection grouting at elliptical concrete pipe crack(s) from (10 to 40) mils in width. Label locations using submitted and approved shop drawing(s). Identify locations and quantities of grout injected at each drilled port.

D. Second Pass: The second pass of injection grouting shall be performed within a few (1-5) minutes after the first pass, in an orderly sequence. This will help ensure all drilled ports have all joint voids and cracks, were not missed.

E. Final Inspection: The final inspection shall be performed after second pass is completed. Submit to Owner, recovery plan for leakage control if said leakage

persists after second pass.

3.2 EXAMINATION

A. Injection Subcontractor to examine substrates and conditions with, COTR representative and injection-material manufacturer for compliance with requirements and for other conditions affecting installation or performance of water control Work.

1. Examine joint and crack widths for determination of which grout types have the appropriate viscosity and will minimize injection pressures and fracking.
2. Ensure that work done by other trades is complete and ready for injection work. If mechanical or electrical equipment or other obstructions block crack and/or pipe joint access, discuss plan to achieve water control goals.
3. Verify that areas and conditions with Injection Subcontractor and representative of injection material manufacturer for compliance with requirements and for other conditions affecting installation or performance of water control Work.
4. Notify COTR, in writing of conditions which may adversely affect installation or performance of injection Work and recommend corrections.
5. Do not proceed with injection Work until adverse conditions have been corrected and reviewed by COTR, and Grouting Consultant (if any).
6. Use GPR or equal to mark locations on concrete of steel reinforcing bar and other buried objects prior to injection port drilling.
7. Commencing injection Work constitutes acceptance of Work surfaces and conditions.

3.3 PROTECTION

A. Protect existing surfaces from injection Work in progress and from mechanical damage due to drilling operations, scaffolding, and/or methods of work and other equipment.

B. Limit access to Work areas. Always wear PPE equipment when using fluids and air under pressure. Wear gloves to avoid skin contact with unreacted grouts. Follow all OSHA and Site Safety protocols.

C. Exercise care to avoid injection or otherwise damaging embedded items. Remove/replace or otherwise remedy damage to embedded items, at no cost to Owner.

3.4 PRESSURIZED INJECTION EQUIPMENT AND PRETESTING

A. Injection equipment shall be capable of pumping injection material under pressure through properly rated hoses and injection ports; equipment shall be approved by injection-material manufacturer.

B. Mark grout component pails and pump intake/discharge lines with color coded tape, colored lines, or designate components of part “A” resins from part “B” resins. Separate mixing devices such that no cross-contamination exists.

C. Use calibrated scale and containers for measuring resins in part “A” and water for part “B” pails. Measure pH and temperature of grouts every eight hours and record on field shop drawings.

D. Perform ratio check on part “A” and part “B” lines prior to any grouting; confer with manufacturer for approval if any ratios are not as specified. Adjust per manufacturer’s instructions and note items on shop drawings.

E. Perform reaction foam/gel time test by mixing part “A” to part “B” resins and noting initial set and viscosity change of mixed grout, document on shop drawings.

3.5 PREPARATION FOR INTERCEPTION GROUTING

A. Inspect surfaces and locate areas to be injected. Locate steel reinforcing mesh/fabric/bar in concrete pipe elements prior to drilling. Survey for suspected utility or electrical lines in concrete.

B. Orient drilling pattern at concrete pipe cracks such that drill hole will intercept midway through the structural element or as shown on contract documents. Drill holes can be staggered from side-to-side or from one-side depending upon accessibility. This requires a drilling angle of 45 degrees from the plane. The spacing is dependent upon concrete element section depth and crack width.

C. Drill holes for injection packers/ports shall be (3/8 to 5/8) inch diameter with coring machine or rotary percussion hammer-drill and bits. Vacuum bits are recommended for silica dust control. Drill hole diameter shall be an appropriable packer diameter match, and/or as shown on the approved shop drawings. After drilling, flush hole with low pressure air, then high pressure water, to rid it of fine dust and debris, which may block the flow of grout into the intercepted crack or joint.

D. Install expandable packers, ball-valve wall spheres, or mechanical ports to achieve spacing pattern as shown by approved shop drawings and provide the following:

1. Number, spacing, and location of drill holes shall be as submitted in the approved shop drawings with noted tolerances.
2. Drill holes for injection ports or packers at 45-degree angle to surface/substrate of interior concrete pipe.
3. Alternate drill hole placement from side-to-side along length of crack or joint at the structural element.
4. If and when a drill hole intercepts a steel object and cannot be advanced, by diamond barrow core drilling, or equal, mark that hole as a “dead hole” and fill it with cementitious grout.
5. Insert expandable packers, wall spheres, or sleeve ports/manchettes into drilled holes in such manner that they are tight, leak free, and are accessible to the injection head.
6. If packer installation cracks or spalls concrete pipe element, re-drill and repeat procedure. Do not inject under pressure at cracked or spalled drill hole locations.

7. Test all drill holes with water prior to starting any chemical grout work. Inject clean water into injection packer with single or dual piston pump to ensure water is displaced at the interior pipe surface. Continue to flush-out any silt/clay accumulation, existing waterproofing, deleterious particles, corrosion byproducts, calcium carbonate, alkali by-products, and various soluble debris in the joint or crack. Pump pressure should not exceed 600 psi for water flushing, otherwise the crack will be subject to hydro-fracture, and damage, creating secondary cracking or joint movement.
8. If water does not flow from crack or joint surface, remove packer from hole: consider drilling hole deeper into element to ensure void/crack or joint was intercepted; re-flush hole with water to rid drilling debris, re-set packer, repeat process.
9. Monitor pressure and time to surface flow of water to gain knowledge of subsequent grouting requirements.
    a. After water flushing under pump pressure is complete, flush with air pressure as noted below:
    b. Continue to flush all water filled drill holes with compressed air pressure at about (100 to 200) psig. Crack or joint shall bubble with entrapped air in the flushing water. Upon completion, chemical grout flushing is complete.

3.6 EXPANDABLE AND TAPERED SHAFT BALL VALVE PACKERS

A. Perform grouting Work in presence of representative of injection-material manufacturer. At conclusion of Work, manufacturer's representative shall prepare and furnish letter or report to COTR, stating whether installation was completed in accordance with requirements. These manufacturer's services shall be provided at no additional cost to Owner.

B. Mix chemical grout components per manufacturers requirements in separate and clean pails. Place dams and spill containment under pump and mixed grout pails. Add colorants or dyes to grout for identification purposes.

C. Maintain conditions and injection material at adequate temperature for suitable time so that injection material will completely fill drill hole or voids, and will achieve full cure.

D. Using the lowest possible pump pressure to achieve desired result, continuously inject material into packers to avoid fracking the concrete element, and as recommended by injection-material manufacturer.
    1. Start injection at lowest packer elevation and move to higher elevations, continue until injection material reaches the pre-calculated volumes and flows from the mouth of crack or joint. Follow procedures outlined in 3.1.
    2. Use injection pressure of 100 to 300 psi (pounds per square inch), depending on port spacing, width of crack, depth of grouting, and condition(s) of concrete. Increase pressure in 100 psi increments to achieve grout flow.
    3. Continue injection process from port-to-port, monitoring grout volume and ensure grout pump pressures do not exceed 600 psig.
    4. Immediately after "Second Pass" of grouting, inject water in

controlled fashion to flush out injection port.

5. Remove injection head after injection material initially sets and reaches the pre-calculated volumes per port and has cured.

3.7 SHUT-DOWN AND PUMP FLUSHING

A. Upon completion of drill hole injection protocol including passes 1 and 2, remove intake lines from grout pails and flush pump with manufacturers approved, solvent, flushing agent. Flushing agent may be water in some cases.

B. Upon completion of pump flushing, fill lines and cylinders with manufacturers approved lubrication and corrosion resistant medium.

C. Remove reacted chemicals and waste flushing agents from the site and dispose at appropriate land fill.

3.8 DRILL HOLE RESTORATION

A. Upon completion of drill hole injection protocol including passes 1 and 2, remove ports/packers, if not done previously, from injected crack or joint locations. Ensure all grout has fully cured prior to packer removal.

B. Re-drill existing injection holes to remove all cured grout in each location. Flush drill hole with pressurized air and water to clean. Wear protective face shields and collect debris from holes with vacuum unit or similar.

C. Mix cement based crystalline waterproofing mortar in clean pail and dry pack into each drill hole with wood rod. Compact mortar into drill hole flush with concrete substrate.

D. Clean surface of injected crack and/or joint prior to demobilization. Remove reacted chemicals and waste flushing agents from the site and dispose of debris off site to a legal dump facility.

3.9 CLEANING

A. Protect existing interior surface finish(s) from grout stains.

B. Clean surfaces of excess grout, and injection ports or packers.
1. Allow injection material enough time to cure before performing cleanup.
2. Clean surfaces by grinding or other means.
3. Ensure all holes are patched at all injection ports.

PART 4 - CONTRACTOR'S QUALIFICATIONS AND QA/QC REQUIREMENTS

4.1 GENERAL

A. Inspection:

1. Manufacturer's representative to inspect completed application and provide a written report that application complies manufacturer's instructions.

B. Product:
1. Supply and install only products specifically designed and manufactured for this type of construction.
2. Select manufacturers of accessory products who are regularly engaged in the production of similar materials for underground structures.

C. Supervision and Training of Personnel:
1. Execute all installation and testing under the direct supervision of an individual with minimum five (5)-years-experience in the installation of grouting systems for underground structures using injection materials as specified.
2. Provide trained personnel for installation and testing operations.
3. The installer must have a minimum of five (5) years of experience at installation of grouting/injection materials in underground installations.
4. The proficiency of each technician shall be demonstrated in the field for approval by the Contracting Officer's Technical Representative (COTR).
5. The grouting system(s) shall be applied only by an approved contractor authorized by the Manufacturer prior to bid.
6. All work shall be completed by trained and authorized personnel.
7. Installation of grouting/injection system(s) shall be the responsibility of the Grouting Applicator to ensure undivided responsibility.
8. Upon request, the Applicator must submit a list of jobs performed by his employees and supervisors similar to the proposed system being bid.

D. Manufacturer's Performance:
1. Shall have documented experience of a minimum of 100,000 square feet or similar.
2. The grouting/injection products are to made by a nationally-recognized manufacturer specializing in water control systems; have been used successfully on projects similar to this; and are appropriate for the substrate, groundwater, hydrostatic pressure, and soil and rock contamination conditions that may be expected in this Contract.

E. Installation Contractor:
1. Installation contractor of grouting materials be certified shall and/or be approved by the manufacturer in writing prior to bid submission.

1.2 FIELD QUALITY CONTROL

A. Installer's quality assurance technician shall be present during grouting work.

B. Provide documentation on the following:
1. Access and location of Work.
2. Materials for sampling.
3. Site facilities for sampling, testing, and storage of materials.

4. Incidental labor.

C. Sample each batch of material to be injected to determine reaction times: Obtain 1 sample of injection material prior to beginning injection Work each day, representing first 50 feet of work, and 1 sample for every 50 feet of injection thereafter. Provide the following:
   1. Allow samples to cure. The reaction should start after ± 60 seconds and end after ± 4:30 seconds.
   2. Do not begin injection Work each day until initial sample has satisfactorily cured.
   3. Label samples with injection date and location of injected packer represented by sample.
   4. Retain samples in a safe location on site.

D. Monitor and Report:
   1. Ambient temperatures,
   2. Grout consumption per packer,
   3. Equipment pressures, and
   4. Material ratios.

END OF SECTION 03 64 10

Section 03 64 13 -- Polyurethane Grout, Crack-Joint Injection

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes polyurethane grout injection for sealing against water leakage and solidifying soil particles on all elliptical concrete culvert pipe joints as shown in “Series A” drawings. Polyurethane grout is designed to seal pipe joint concrete cracks, adhere to asphalt mastic, fill voids in joints and concrete side walls.

B. Work of this section will be designated on drawings as WP-1 and is shown and itemized in Scope-of-Work section on Construction Documents.

C. Related Sections: Other specification sections, which directly relate to the Work of this Section and include, but are not limited to, the following:
1. Section 03 64 13 Polyurethane Grout, Crack-Joint Injection, WP-1
2. Section 03 64 20 Acrylamide Grout Joint Injection, Soil Solidification, WP- 2
3. Section 03 61 10 Ultra-fine Cement, Soil Stabilization, SS-3
4. Section 07 16 16 Crystalline Waterproofing, WP-4
5. Section 03 64 10 Polyacrylate Grout Crack Injection, WP-5
6. Section 03 64 23 Epoxy Resin Crack Injection, WP-6
7. Section 07 13 56 Thermoplastic Sheet Strip Seals, WP-7

D. Contractor shall be responsible for reviewing site conditions to verify quantities.

E. Contractor shall be responsible for magnitude (depth and width), scope (length) of elliptical concrete pipe joint filling and sealing for water and sand control as schematically shown and outlined on contract documents.

F. Contractor shall follow prescriptive requirements of this specification; however, Contractor may modify as necessary the procedures, products, and installation to achieve water and sand control through the leaking concrete culvert pipe joints if approved via shop drawings.

1.2 SECTION INCLUDES

A. Injection grouting to minimize water leakage and sand piping through elliptical culvert pipe joints post construction and is organized as follows:
1. Examination
2. Preparation and Layout
3. Drilling Injection Ports
4. Air-flushing drill holes
5. Water-flushing drill holes
6. Setting Injection Ports
7. Pressurized Water Testing
8. Pressurized Air Testing
9. Conditions Where Excessive Leakage Occurs
10. Injection Grouting Operations

11. Re-Drilling drill holes
12. Water-flushing drill holes
13. Mortar filling drill holes
14. Clean-up and Demobilization

1.3 REFERENCES

A. Reference Standards: Latest edition as of Specification date.
   1. American Society for Testing and Materials (ASTM) - ASTM International:
      a. ASTM C42/C42M: Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
      b. ASTM C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
      c. ASTM D420: Standard Guide for Investigating and Sampling Soil and Rock.
      d. ASTM D2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
      e. ASTM F2304 Standard Practice for Rehabilitation of Sewers using Chemical Grouting (latest revision).
      f. ASTM F2454 Standard Practice for Sealing Lateral Connections and lines from the mainline Sewer Systems by Lateral Packer Method, Using Chemical Grouting (latest revision).
      g. ASTM C507 Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
      h. ASTM C1840 Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain and Storm Sewer Pipe.

B. Department of Labor, Occupational Safety and Health Administration (OSHA), Occupational Safety and Health Standards – Excavations, Final Rule – 29 CFR, Part 1926

C. American National Standards Institute (ANSI):
   1. Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD). Z535.1 Safety Color Code

D. American Public Works Association (APWA):
   1. Uniform Color Code for Temporary Marking of Underground Utility Locations.

E. Other Applicable Standards:
   1. National Association of Sewer Service Companies (NASSCO) prepared Pipeline Assessment and Certification Program (PACP), TV inspection form and sewer condition codes.

1.4 ABBREVIATIONS:

A. Commonly used abbreviations used in this specification are as follows:
   1. OR – Owners Representative
   2. CO – Contracting Officer
   3. COR: Contracting Officer's Representative.

4. COTR – Contracting Officer's Technical Representative
5. M/E/P – Mechanical Electrical Plumbing
6. SPI – Safety Performance Index
7. EDR – Engineering Design Representative
8. SDS – Safety Data Sheet
9. HEPA -- High Efficiency Particulate Air
10. mm – millimeters (40 mils = 1 mm)
11. mil – millage, 1/1,000 inch = 0.001"
12. QA – Quality Assurance
13. QC – Quality Control
14. WP – Waterproofing
15. SS – Soil Solidification/Stabilization

1.5 SECTION INCLUDES

A. The Work shall be performed in the following order and as documented in the contract documents.
   1. Examination
   2. Preparation and Layout
   3. Drilling Injection Ports
   4. Air-flushing drill holes
   5. Water-flushing drill holes
   6. Setting Injection Ports
   7. Pressurized Water Testing
   8. Pressurized Air Testing
   9. Conditions Where Excessive Leakage Occurs
   10. Injection Grouting Operations
   11. Re-Drilling drill holes
   12. Water-flushing drill holes
   13. Mortar filling drill holes
   14. Clean-up and Demobilization

1.6 DEFINITIONS

A. Specification criteria:
   1. Prescriptive based-water control criteria established by design professional's details and specifications, or
   2. Performance based- water control ways-and-means established by contractor and reviewed by design professional.

B. Water leakage nomenclature:
   1. Crack Root-The point(s) of water ingress into a concrete element.
   2. Crack Mouth- The points of water discharge from a concrete element.
   3. Trail- A noticeable pathway/stain on concrete element surface designating continuous water flow.
   4. Ponding- The accumulation of water leakage through a concrete element.

C. Five levels of water accumulation on a concrete element can be physically described as follows:

1. Color change (darker), when high moisture content exists at concrete element surface, (white/crystalline or efflorescence) when area has re-sealed itself via autogenous healing), not visually wet to touch, no ponding occurs;
2. Wet to touch, surface dampness in spots, no sustained water trail present, or, no ponding occurs;
3. Weeps and seepage, sustained trail of wetness, however, visual surface flow not apparent, ponding does occur;
4. Continuous dripping, visual surface flow or water movement over Gushing concrete element, ponding occurs and leaves trail; or
5. Flow, from presence of hydrostatic back pressure, ponding leaves continuous trail of water.

D. Water Control: Water control at concrete elements serves many purpose(s):
1. Minimizes potential of dissolved oxygen, carbon dioxide, free chlorides and various salts/contaminants from entering concrete through-wall/floor/elevated-deck cracks and joints.
2. Helps control and potentially mitigate the following:
   a) Internal steel reinforcing bar corrosion,
   b.) Hardware corrosion of externally attached metal adjacent to wet area
   c.) Concrete carbonation, and
   d.) Alkali Silica Reactivity and Delayed Ettringite Formation.
   e.) Surface delamination of paints, coatings and high build flooring components,
   f.) Nutrient Source for mold, algae, and bacterial growth organisms,
   g.) Interior surface stains, efflorescence, salt and carbonate buildups (stalactites/stalagmites),
   h.) Ice formation (icicles) in unheated enclosures,
   I.) Slippery surfaces,
   j.) Electrical short circuits, and/or shocks,
   k.) Conductor for stray current corrosion,
   l.) Potential soil particle loss, and
   m.) Costly cleanup when hazardous contaminants (radioactive or poisonous hydrocarbons) enter and accumulate.

E. Structural Parameters: Three important considerations for successful grouting without damaging the structural concrete elements are as follows:
1. Pressures more than 600 psig can cause tensile damage (fracking) to existing concrete elements,
2. Crack/joint width is inversely proportional to pump gauge pressure, and
3. Crack/joint width is proportional to grout viscosity required for proper penetration

F. Typical water leakage flow paths at the following locations:
1. Through-element, primary and secondary, cracks/joints;
2. Voids and shadows along/under horizontal or vertical steel reinforcing bar;
3. Unbonded surfaces between concrete and mechanical, electrical, plumbing, penetrations, (MEP) inserts, or sleeves and dewatering hardware;
4. Poorly consolidated and/or honeycombs within concrete element at

cold and/or construction joints;
5. Porous foreign objects/debris and/or soil deposits trapped within the concrete element during forming/placement construction and subsequent placement;
6. Through element braided wire copper ground cables; and
7. Form-tie brackets, anchors, wire, or any such temporary or permanent structural inserts.

G. Crack Nomenclature and Width Definitions:
1. Cracks and joints as fine as 1/1000 inch (1 mil) are subject to water leakage if hydrostatic back pressure exists. Water leakage volumes are related to hydrostatic pressure, crack/joint width, and internal friction at crack/joint sidewalls. Cracks and joints are defined as follows:
   a. ultra-fine crack/joint (01 to 05) mils (0.025 to 0.127) mm
   b. very-fine crack/joint (06 to 10) mils (0.152 to 0.254) mm
   c. fine crack/joint (11 to 15) mils (0.279 to 0.381) mm
   d. medium-fine crack/joint (16 to 20) mils (0.406 to 0.508) mm
   e. medium crack/joint (21 to 40) mils (0.533 to 1.016) mm
   f. medium-wide crack/joint (41 to 60) mils (1.041 to 1.524) mm
   g. wide crack/joint (61 to 120) mils (1.549 to 3.048) mm

H. Grout(s): Generic term describing various - structural and/or non-structural, cementitious and/or non-cementitious materials which are installed as a liquid, paste or gel/mastic; which may cure-out as a product that exhibits a high or low modulus resulting in an elastic/plastic foam, gel, or paste-like matrix. Injection or placement materials include Portland cement (Types I, II, III, IV, or V, with or without fine aggregate, neat cement as micro-fine and ultra-fine in particle size) and/or bentonite powder blends, potassium/sodium silicates, reactive polymer(s), such as urethane (hydrophobic/hydrophilic), epoxy, methyl-methacrylate, acrylamide and polyacrylate resins, solvent (hydrocarbon or water) based rubber gels, and hot/cold asphalt fluids and/or emulsions. Grout viscosity has a relationship with pumping pressure and crack width, among other parameters such as temperature, cross-sectional width of voids, gel-time, and water chemistry. Four grout designations are as follows:
1. Low viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material when initially mixed facilitates a viscosity of (1 to 15) centipoise. Said grouts under controlled pressure penetrate ultra-fine cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.
2. Medium viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material when initially mixed facilitates a viscosity of (50 to 100) centipoise. Said grouts under controlled pressure penetrate fine cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.
3. High viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material when initially mixed facilitates a viscosity of (500 to1,000) centipoise. Said grouts under controlled pressure penetrate medium-wide cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.

4. Very-high viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material or non-reactive fluid when initially mixed facilitates a viscosity of (2,000 or greater) centipoise. Said grouts under controlled pressure penetrate wide cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.

I. Interception Grouting: Process by which a crack or joint is intercepted between its mouth and root (origin), and further a chemical grout is pumped into it under gauge pressure to fill any void space left in the concrete matrix.

J. Permeation Grouting: Process of injecting chemical grout under pressure filling the pore space of soil particles in a specified zone of influence; also referred to as soil solidification, chemical grouting, curtain grouting, and/or pressure.

K. Grout Curtain: A solidified soil element (of length, width, and depth) having low permeability qualities.

L. Sectioning: Grout curtain in soil strata arranged to seal off individual structural sections. Used in connection with “charge” and “re-charge” grouting pipes to create a grout curtain system, which promotes control of watertightness and facilitates leakage remediation.

M. Charge and Re-Charge Pipes: Drilled holes for permeation grouting process. Charge holes are pressurized with grout and re-charge holes allow pressure relief and monitoring of grout path; also referred to as “inlet/outlet” ports.

N. Control and Grouting Pipes: Pipes typically installed near water barrier intersections to control water-tightness of individual waterproof membrane sections. If leakage should occur, the pipes are used for remedial grouting specifically located at each connection or interruptions to concrete pours; also referred to as “inlet/outlet” ports.

O. Sleeve Port(s): Injection pipe(s) of various diameters with incremental openings (perforated pipe) along its length, covered with a rubber gasket; also called manchette tube or Tube-A-Manchette (TAM).

P. Manchette tube: Tube-A-Manchette (TAM) or commonly referred to as Injection pipe(s) of various diameters with incremental openings along its length, covered with a rubber gasket; also called a sleeve port.

Q. Packer(s): A mechanical device placed into or through drilled holes in concrete elements or driven into soil, through which grout is pumped into, and forced through; also referred to as injection port, expandable packer, or wall sphere. Devices shall be chemical resistant HDPE (high density polyethylene), neoprene rubber, leather or Teflon gaskets, and stainless-steel, brass, aluminum, or carbon steel frame. Most contain a grease zerk, button head, or quick-connect for attachment to the Injection head.

R. Slide Packer(s): A mechanical device placed into plastic manchettes with sectionalized inflatable or friction gaskets (leather or Teflon) at each end to

control and distribute pressurized grout to incremental location(s) within the manchette or sleeve port.

S. Injection Head or Gun: Mechanical device consisting of a mixing chamber for one or more parts of resin with quick-connects, zerk grease fitting, button head, and an on/off switch or ball-valve to control flow and capability, recirculation, pressure monitoring, and a cleanout; often called an “E” or “F”-Assembly.

U. Crystalline Waterproofing Mortar: Portland cement/silica sand mortar with reactive chemical admixture that promotes crystalline growth in the reinforced element. Reactive chemicals combine the free calcium hydroxide in concrete to crystallize and imped water flow.

V. Grouting Procedure:
1. Top-down Grouting: Injection technique whereby grout curtain is established near ground or exposed surface, once that solidifies, manchettes are drilled through the solidified zone and grouting proceeds sequentially downward.
2. Bottom-up Grouting: Technique whereby grout curtain is established at bottom of hole and manchettes are sequentially lifted and grout zone proceeds upward.

W. Grouting Installation Form: Form provided by Contractor, documenting the location and amount of grout in each manchette location.

X. Dual and Single Component Pump(s): Operated with compressed air, electric, hydraulic oil, or mechanically operated pump with single mechanism or multi-ratio mechanisms for pumping various grout components.

Y. Quality Control: A system for verifying and maintaining a desired level of quality in an existing product or service by careful planning, use of proper equipment, continued inspection, and corrective action as required.

Z. Quality Assurance: A systematic monitoring and evaluation program for various aspects of a project, service, or facility to ensure that standards of quality are being met.

1.7 SUBMITTALS

A. Shop Drawings: Provide project customized plan, sections and associated details showing the following:
1. Work scope plan if different from contract documents.

B. Product Data: Injection grout material manufacturer’s literature (catalogue cuts) including.
1. Written instructions for handling, mixing, and safety procedures.
2. Technical data including tested physical and performance properties, including:
a. Temperature ranges for storage and application of materials, and special warm/cold-weather application requirements or limitations,
b. Include recommended Site protection measures, and

c. Safety Data sheets.

C. Certificates:
1. Signed by injection-material manufacturer, certifying that products furnished comply with requirements and are recommended by manufacturer for uses indicated.
2. Signed by injection-material manufacturer, certifying that individual(s) performing work is approved to install its products.

D. Injection Installer/Subcontractor Qualifications: Evidence that Subcontractor's existing company has minimum 5 years of continuous experience in injection of specified materials; list of at least 5 representatives, successfully completed projects of similar scope and size, including:
1. Project name.
2. Owner's name.
3. Owner's Representative name, address, and telephone number.
4. Description of work.
5. Injection materials used.
6. Equipment used.
7. Project supervisor.
8. Total cost of injection work and total cost of project.
9. Completion date.

E. Installer/Subcontractor's and/or Manufacturer's field reports.

F. Resume' of chemical grouting installation supervisor.

G. Samples: Reacted Chemical Grout in small plastic bottle.

H. Chemical Grouting protection plan/narrative: Describe the intended procedures to prevent damage during construction operations. The following items shall be addressed:
1. Storage and set up of equipment,
2. Restoration of drill holes,
3. Steel reinforcing location plan,
4. Handling of drilling fluids and waste products if any, and
5. Testing to ensure continuous and monolithic grout pattern.

1.8 QUALITY ASSURANCE REQUIREMENTS

A. Personnel identified during prequalification process shall be the personnel conducting the Work.

B. Pre-installation Meeting:
1. Conduct meeting at Site.
2. Review requirements for injection Work, including:
a. Safety protocol and tradesmen training,
b. Construction schedule,
c. Availability of materials, Injection Installer/Subcontractor's personnel, equipment, and facilities needed to make progress and avoid delays.

d. Site use, access, staging and set-up location/limitations.
e. Cracks and joints to be injected, and condition of other construction activity that will affect injection Work.
f. Injection procedures.
g. Testing and inspection requirements.
h. Site protection measures.
i. Governing regulations.

C. Contractor's Site superintendent, injection-material manufacturer's technical representative, Injection Subcontractor's foreman, COR, COR's Representative, and Grouting Consultant, shall attend.

1.9 WEATHER LIMITATIONS

A. Environmental Limitations: Install injection material when existing and forecast weather conditions permit material to be installed and cured according to injection-material manufacturer's written instructions and warranty requirements.

B. Do not install when air and substrate temperatures are outside limits permitted by injection-material manufacturer. Provide enclosures to ensure against freezing temperatures and or over exposure to UV light, unless approved in writing by injection-material manufacturer.

C. Do not work in severe temperatures, moisture, and excessive humidity; these may affect the installation and performance of products during construction. Consult with Manufacturer's Representative and comply with applicable material recommendations for workmanship and handling.

D. Contractor/Grouting Installer shall be aware that un-managed water can be a safety issue.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials according to manufacturer's recommendations and in such manner as to prevent damage to materials and existing structure.

B. Deliver materials to Site in original containers with seals unbroken, labeled with manufacturer's name; product brand name and type; date of manufacture; lot number; SPI hazardous rating and appropriate warnings for handling; and directions for storing and mixing.

C. Keep materials dry and do not allow materials to be exposed to moisture during transportation, storage, handling and installation. Reject and remove from Site new materials which exhibit evidence of moisture reaction during application or have been exposed to abuse or other deleterious materials.

D. Store materials in original, undamaged containers in clean, dry, protected location on raised platforms with weather-protective coverings, within temperature range required by injection-material manufacturer.

E. Limit stored materials on structures to safe loading capacity of structure at time materials are stored, and to avoid permanent deck deflection.

F. Conspicuously mark damaged or opened containers with contaminated materials, and remove from Site as soon as possible. Dispose containers to legal dump site.

G. Remove and replace materials that cannot be installed within stated shelf life.

1.11 PROJECT CONDITIONS AND SAFETY PROTOCOL

A. Verify existing dimensions and any known utilities (buried drainpipes, electrical or telecom service) prior to start of injection Work. Notify COR, if conditions found to be different than those indicated in Contract Documents. Be aware of buried utilities, (drainpipes, electrical or telecom service) unknown at time of drilling.

B. If unusual or concealed conditions are discovered, stop work and immediately notify COR in writing. Be aware of private drain line pipes and fields.

C. Provide adequate ventilation and protect adjacent building air intakes (if any) to ensure no adverse effects from grout fumes, smells, or odors. Note the following:
1. Acrylic grout oxidizers give off an ammonia smell/vapor,
2. Urethane grouts give off MDI or TDI smell/vapors,
3. Carbon dioxide is released as part of polyurea/polyurethane reaction,
4. Hot asphalt can give off benzene vapors and hydrocarbon smells,
5. Bentonite and cement grouts give off silica dust when mixing with water,
6. Hydrocarbon solvents are released when used as a viscosity reducer,
7. Drilling into concrete produces silica dust, and
8. Adding ethylene glycol to air intake lines of grout pump can produce hydrocarbons in the immediate area.

D. Follow OSHA regulations during work performance, and particularly when the following occurs:
1. Trades people are working on platforms and scaffolding,
2. Heights more than four feet,
3. When using ladders,
4. When drilling into concrete and creating sparks and dust,
5. Use OSHA approved HEPA dust collection systems when drilling into concrete elements,
6. Wear goggles, face shields, or similar when high grout pressures are used, and
7. Wear proper PPE clothing and gloves when handling solvent, hot, and/or reactive chemicals.

PART 2 – MATERIALS

2.1 PRODUCTS

A. Source Limitations: Obtain injection materials through single manufacturer as

much as possible, and/or from sources approved by manufacturer of injection material.

B. Approved Products and Chemical Grout Manufacturers/Suppliers:
   1. AV-202 by Avanti International, 822 Bay Star Blvd., Webster TX. 77598 Phone: 800-877-2570 Fax: 281-486-7300 (Basis for Design)
   2. Aquafin InjectProECO-Polygel by Aquafin, Inc., 505 Blue Ball Road, No.160, USA - Elkton, MD 21921, Phone: (410) 392-2300, Fax: (410) 392-2324

C. Or-equal grout manufacturer. Products shown to be equal in viscosity, solids percentage, chemical composition, and performance are of consideration by Specifying Engineer. Approved equal products must be approved in writing prior to bid proposal.

D. Approved Products for sealing tops of drill holes:
   1. Aquafin Mortar IC or Aquafin-Plug-IC by Aquafin, Inc., 505 Blue Ball Road, No.160, USA - Elkton, MD 21921.

E. Auxiliary Materials:
   1. Epoxy gel: Use 1 of following or approved equal:
      a. SCB Concresive 1446 manufactured by BASF Construction Chemicals, LLC.
      b. AV-202 by Avanti International, 822 Bay Star Blvd., Webster TX. 77598 Phone: 800-877-2570 Fax: 281-486-7300
      c. Prime Gel 2000 High Mod manufactured by Prime Resins, Inc.
      d. Sikadur 31, Hi-Mod Gel manufactured by Sika Corporation.
   2. Crystalline Waterproofing Mortar: Use the following or approved equal:
      a. Aquafin 1C mortar
      b. Aquafin-Plug-IC
   3. Hydraulic cement: Use one of following or approved equal:
      a. Aquafin-Plug-IC, manufactured by Aquafin Inc.
      b. Water plug manufactured by BASF Construction Chemicals, LLC. SikaPlug Fast-Setting Water Stop manufactured by Sika Corporation.
   4. Oakum:
      a. As recommended by the Grout Manufacturer.
   5. Grouting Equipment and Accessories:
      a. Stainless Steel, 1-to-1 ratio, dual piston pump, with pressure control gauges for hydrophilic urethane, acrylamide and polyacrylate grouts.
      b. Stainless steel diaphragm pumps for supplying grout to pump from mixing barrows if necessary.
      c. Stainless steel “E” or “F”-Assembly with check and ball valves.
      d. Chemical resistant, insulated injection hose lines for work in cold or hot weather.
      e. Grease zerk or button head expandable packers to match drill hole size.
      f. HDPE and/or stainless-steel mixing barrows and paddles.
      g. Stainless steel packers with needle extensions where required for

localized grout conditions.

h. Water and/or liquid control meters for grout volume monitoring.

PART 3 - EXECUTION

3.1 GROUTING PHASES AND GENERAL WORK SCOPE

A. Perform injection grouting operations at all elliptical concrete culvert pipe joint locations and as shown on “Series A” drawings in contract documents.

B. First Pass: Perform injection grouting all elliptical concrete pipe joint areas. Label locations using submitted and approved shop drawing(s). Identify locations and quantities of grout injected at each drilled port.

C. Second Pass: The second pass of injection grouting shall be performed within a few (1-5) minutes after the first pass, in an orderly sequence. This will help ensure all drilled ports are injected to ensure grout “take” and voids were not missed.

D. Third Pass: The third pass of hydrophilic urethane injection grouting shall be performed after acrylamide grout has been injected and if water or grout leaks through joints. Re-grout all locations where water leakage continues to persist and label locations using the approved shop drawing(s).

E. Final Inspection: The final inspection shall be performed after third pass is completed. Submit to Owner, recovery plan for leakage control if said leakage persists after third pass.

3.2 EXAMINATION

A. Injection Subcontractor to examine substrates and conditions with, COR representative and injection-material manufacturer for compliance with requirements and for other conditions affecting installation or performance of water control Work.

1. Examine crack and joint widths for determination of which grout types have the appropriate viscosity and will minimize injection pressures and fracking.
2. Ensure that work done by other trades is complete and ready for Injection work. If mechanical or electrical equipment or other obstructions block crack and/or joint access, discuss plan to achieve water control goals.
3. Verify that areas and conditions with Injection Subcontractor and representative of injection material manufacturer for compliance with requirements and for other conditions affecting installation or performance of water control Work.
   Notify COR, in writing of conditions which may adversely affect installation or performance of injection Work and recommend corrections.
4. Do not proceed with injection Work until adverse conditions have been corrected and reviewed by COR, and Grouting Consultant (if any).
5. Use GPR or equal to mark locations on concrete steel reinforcing bar. and other buried objects prior to injection port drilling.

6. Commencing injection Work constitutes acceptance of Work surfaces and conditions.

3.3 PROTECTION

A. Protect existing surfaces from injection Work in progress and from mechanical damage due to drilling operations, scaffolding, and/or methods of work and other equipment.

B. Limit access to Work areas. Always wear PPE equipment when using fluids and air under pressure. Wear gloves to avoid skin contact with unreacted grouts. Follow all OSHA and Site Safety protocols.

C. Exercise care to avoid injection or otherwise damaging embedded items. Remove or replace or otherwise remedy damage to embedded items, at no cost to Owner.

3.4 PRESSURIZED INJECTION EQUIPMENT AND PRETESTING

A. Injection equipment shall be capable of pumping injection material under pressure through properly rated hoses and injection ports; equipment shall be approved by injection-material manufacturer.

B. Mark grout component pails and pump intake/discharge lines with colored coded tape, colored lines, or designate components of part “A” resins from part “B” resins. Separate mixing devices such that no cross-contamination exists.

C. Use calibrated scale and containers for measuring accelerators in part “A” and hardeners for part “B” resin pails. Measure pH and temperature of grouts every two hours and record on the shop drawings.

D. Perform ratio check on part “A” and part “B” lines prior to any grouting; confer with manufacturer for approval if any ratios are not as specified. Adjust per manufacturer’s instructions and note items on shop drawings.

E. Perform reaction foam/gel time test by mixing part “A” to part “B” resins and noting initial set and viscosity change of mixed grout, document on shop drawings.

3.5 PREPARATION FOR INTERCEPTION GROUTING AT JOINTS

A. Inspect surfaces and locate areas to be injected. Locate steel bar in concrete elements prior to drilling.

B. Orient drilling pattern at concrete pipe joints such that drill hole will intercept midway through the structural element and as shown on the contract documents. Drill holes can be staggered from side-to-side or from one-side depending upon accessibility. Drill approximately 6 inches deep into the 8.5-inch deep joint section. Ensure the joint is intersected.

C. Drill holes for injection packers/ports shall be (3/8 to 5/8) inch diameter with coring machine or rotary percussion hammer-drill and bits. Vacuum bits are recommended for silica dust control. Drill hole diameter shall be matched with an appropriable packer diameter, and/or as shown on approved shop drawings. After drilling, flush hole with low pressure air, then water, to rid it of fine dust and debris, which may block the flow of grout into the intercepted joint.

D. Install expandable packers, wall spheres, or sleeve ports/manchettes to achieve spacing pattern as shown by approved shop drawings and provide the following:
1. Number, spacing, and location of drill holes shall be as submitted in the approved shop drawings with noted tolerances.
2. Drill holes for injection ports or packers at 90-degree angle to surface. Alternate drill hole placement from side-to-side along length of joint at the structural element.
3. If and when a drill hole intercepts a steel object and cannot be advanced, mark that hole as a “dead hole” and fill with cementitious grout and re-drill.
4. Insert expandable packers, wall spheres, or sleeve ports/manchettes into drilled holes in such manner that they are tight, leak free, and are accessible to the injection head.
5. If packer installation cracks or spalls the concrete element, re-drill and repeat procedure. Do not inject under pressure at cracked or spalled drill hole locations. Repair spalled concrete at joints.
6. Test all drill holes with water pressure (5-to-10 psig minimum) prior to starting any chemical grout work. Inject clean water into injection packer with single or dual piston pump to ensure water gauge pressure is established or is displaced at the surface. Continue to flush-out any silt/clay accumulation, existing soil debris, deleterious asphalt particles, corrosion byproducts, calcium carbonate, alkali by-products, and/or soluble debris in the joint.
7. If water does not flow from joint surface, remove packer from hole: consider drilling hole deeper into element to ensure void or joint was intercepted; re-flush hole with water to rid drilling debris, re-set packer, repeat process.
8. Monitor pressure and time to surface flow of water to gain knowledge of subsequent grouting requirements.
    a. After water flushing under pump pressure is complete, flush with air pressure as noted below.
    b. Continue to flush all water filled drill holes with compressed air pressure at about (100 to 200) psi. Joint shall bubble with entrapped air in the flushing water. Upon completion, chemical grout flushing is complete.

3.6 EXPANDABLE AND TAPERED SHAFT BALL VALVE PACKERS

A. Perform grouting Work in presence of representative of injection-material manufacturer. At conclusion of Work, manufacturer’s representative shall prepare and furnish letter or report to COR, stating whether installation was completed in accordance with requirements. These manufacturer’s services shall be provided at no additional cost to Owner.

B. Mix chemical grout components per manufacturers requirements in separate

and clean pails. Place dams and spill containment under pump and mixed grout pails. Add colorants or dyes to grout for identification purposes.

C. Maintain conditions and injection material at adequate temperature for suitable time period so that injection material will completely fill the drill hole or void and will achieve full cure.

D. Using the lowest possible pump pressure to achieve desired result, continuously inject material into packers to avoid fracking the concrete element, and as recommended by injection-material manufacturer.
   1. Start injection at lowest packer elevation and move to higher elevations, continue until injection material reaches the pre-calculated volumes and flows from joint mouth. Follow procedures outlined in 3.1 (above).
   2. Use injection pressure of 10 to 30 psi (pounds per square inch), depending on port spacing, width of joint, depth of grouting, and condition(s) of concrete. Increase pressure in 10 psi increments to achieve sufficient grout flow.
   3. Continue injection process from port-to-port, monitoring grout volume and ensure grout pump pressures do not exceed 60 psig.
   4. Immediately after “Second Pass” of grouting, inject water/hydrocarbon solvent in controlled fashion to flush out injection port.
   5. Remove injection head after injection material initially sets and reaches the pre-calculated volumes per port and has cured.

3.7 SHUT-DOWN AND PUMP FLUSHING

A. Upon completion of drill hole injection protocol including passes 1 and 2, remove intake lines from grout pails and flush pump with manufacturers approved, solvent, flushing agent. Flushing agent may be water in some cases.

B. Upon completion of pump flushing, fill lines and cylinders with manufacturers approved lubrication and corrosion resistant medium.

C. Remove reacted chemicals and waste flushing agents from the site and dispose at appropriate land fill.

3.8 DRILL HOLE RESTORATION

A. Upon completion of drill hole injection protocol including passes 1 and 2, remove ports/packers, if not done previously, from injected joint locations. Ensure all grout has fully cured prior to packer removal.

B. Re-drill existing injection holes to remove all cured grout in each location. Flush drill hole with pressurized air and water to clean. Wear protective face shields and collect debris from holes with vacuum unit or similar.

C. Mix cement based high strength mortar in clean pail and dry pack into each drill hole with wood rod. Compact mortar into drill hole flush with concrete substrate.

D. Clean surface of injected joint prior to demobilization. Remove reacted chemicals and waste flushing agents from the site and dispose of debris off site to a legal dump facility.

3.9 CLEANING

A. Protect existing surface finish(s) from grout stains.

B. Clean surfaces of excess grout, and injection ports or packers.
1. Allow injection material enough time to cure before performing cleanup.
2. Clean surfaces by grinding or other means.
3. Ensure all holes are patched at injection ports.

PART 4 - CONTRACTOR'S QUALIFICATIONS AND QA/QC REQUIREMENTS

4.1 GENERAL

A. Inspection:
1. Manufacturer's representative to inspect completed application and provide a written report that application complies manufacturer's instructions.

B. Product:
1. Supply and install only products specifically designed and manufactured for this type of construction.
2. Select manufacturers of accessory products who are regularly engaged in the production of similar materials for underground structures.

C. Supervision and Training of Personnel:
1. Execute all installation and testing under the direct supervision of an individual with minimum five (5)-years-experience in the installation of grouting systems for underground structures using injection materials as specified.
2. Provide trained personnel for installation and testing operations.
3. The installer must have a minimum of five (5) years of experience at installation of grouting/injection materials in underground installations.
4. The proficiency of each technician shall be demonstrated in the field for approval by the Contracting Officer's Technical Representative (COTR).
5. The grouting system(s) shall be applied only by an approved contractor authorized by the Manufacturer prior to bid.
6. All work shall be completed by trained and authorized personnel.
7. Installation of grouting/injection system(s) shall be the responsibility of the Grouting Applicator to ensure undivided responsibility.
8. Upon request, the Applicator must submit a list of jobs performed by his employees and supervisors similar to the proposed system being bid.

D. Manufacturer's Performance:

1. Shall have documented experience of a minimum of 100,000 square feet or similar.
2. The grouting/injection products are to made by a nationally-recognized manufacturer specializing in water control systems; have been used successfully on projects similar to this; and are appropriate for the substrate, groundwater, hydrostatic pressure, and soil and rock contamination conditions that may be expected in this Contract.

E. Installation Contractor:
1. Installation contractor of grouting materials be certified shall and/or be approved by the manufacturer in writing prior to bid submission.

4.2 FIELD QUALITY CONTROL

A. Installer's quality assurance technician shall be present during grouting work.

B. Provide:
1. Access to Work.
2. Materials for sampling.
3. Site facilities for sampling, testing, and storage of materials.
4. Incidental labor.

C. Sample each batch of material to be injected to determine reaction times: Obtain one sample of injection material prior to beginning injection Work each day, representing first 50 feet of injection, and one sample for every 300 feet of injection thereafter. Provide the following:
1. Allow samples to cure. The reaction should start after ± 60 seconds and end after ± 4:30 seconds.
2. Do not begin injection Work each day until initial sample has satisfactorily cured.
3. Label samples with injection date and location of injected packer represented by sample.
4. Retain samples in a safe location on site.

D. Monitor and Report:
1. Ambient temperatures,
2. Grout consumption per packer,
3. Equipment pressures, and
4. Material ratios.

END OF SECTION 03 64 15

Section 03 64 20 -- Acrylamide Grout Joint Injection, Soil Solidification

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes acrylamide grout injection through all concrete culvert pipe joint(s) from invert to crown, to seal against water entry and solidify soil particles on pipe joint perimeter.

B. Work of this section is designated on drawings as WP-2 and is itemized in the Scope-of-Work section on Construction Documents.

C. Related Sections: Other specification sections, which directly relate to Work of this Section include, but are not limited to, the following:
1. Section 03 64 13 Polyurethane Grout, Crack-Joint Injection, WP-1
2. Section 03 64 20 Acrylamide Grout Joint Injection, Soil Solidification, WP- 2
3. Section 03 61 10 Ultra-fine Cement, Soil Stabilization, SS-3
4. Section 07 16 16 Crystalline Waterproofing, WP-4
5. Section 03 64 10 Polyacrylate Grout Crack Injection, WP-5
6. Section 03 64 23 Epoxy Resin Crack Injection, WP-6
7. Section 07 13 56 Thermoplastic Sheet Strip Seals, WP-7

D. Contractor shall be responsible for reviewing site conditions to verify quantities.

E. Contractor shall be responsible for magnitude (depth, length, and width), scope of permeation grouting control as schematically shown and outlined on the contract documents.

F. Contractor shall generally follow prescriptive requirements of this specification; however, Contractor may modify as necessary the procedures, products, and installation to achieve water and soil control through the leaking concrete culvert pipe joints when approved via shop drawings.

1.2 SECTION INCLUDES

A. Injection grouting to minimize water leakage post construction.
1. Examination
2. Preparation and Layout
3. Drilling Injection Ports
4. Setting Injection Ports
5. Injection Grouting Operations
6. Permeation Grouting Verification
7. Remediation Grouting After Verification
8. Clean-up and Demobilization

1.3 REFERENCES

A. Reference Standards: Latest edition as of Specification date.
1. American Society for Testing and Materials (ASTM) - ASTM International:

a. ASTM C42/C42M: Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
b. ASTM C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
c. ASTM D420: Standard Guide for Investigating and Sampling Soil and Rock.
d. ASTM D2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
e. ASTM C507 Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
f. ASTM C1840 Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain and Storm Sewer Pipe.

B. Department of Labor, Occupational Safety and Health Administration (OSHA), Occupational Safety and Health Standards – Excavations, Final Rule – 29 CFR, Part 1926

C. Other Applicable Standards:
1. National Association of Sewer Service Companies (NASSCO) prepared Pipeline Assessment and Certification Program (PACP), TV inspection form and sewer condition codes.

1.4 ABBREVIATIONS:

A. Commonly used abbreviations used in this specification are as follows:
1. OR – Owners Representative
2. CO – Contracting Officer
3. COR – Contracting Officer's Representative
4. COTR – Contracting Officer's Technical Representative
5. M/E/P – Mechanical Electrical Plumbing
6. SPI – Safety Performance Index
7. EDR – Engineering Design Representative
8. SDS – Safety Data Sheet
9. HEPA – High Efficiency Particulate Air
10. mm – millimeters (40 mils = 1 mm)
11. mil – millage, 1/1,000 inch = 0.001"
12. QA – Quality Assurance
13. QC – Quality Control
14. WP – Waterproofing
15. SS – Soil Solidification/Stabilization

1.5 DEFINITIONS

A. Grout(s): Generic term describing various liquid/gel/paste injection materials:
1. Types 1 and/or 3, Portland cement (with or without fine aggregate),
2. Micro-fine and ultra-fine Portland cement,
3. Reactive polymer(s):
a. urethane (hydrophobic/hydrophilic),
b. polyacrylate, methacrylate and acrylamide,
c. epoxy, and

d. silicate based resins.
4. Bentonite blends,
5. Solvent based rubber gels, and
6. Hot/cold asphalt fluids and/or emulsions.

B. Chemical Grout: A low viscosity, reactive, polymer, resin which penetrates soil particle pore space under a gauge pressure; also commonly referred to as grout, injection resin or gel grout.

C. Grouting Types and Procedures:
1. Interception Grouting: Process by which a crack or joint is intercepted between its mouth and root (origin), and further a chemical grout is pumped into it under gauge pressure to fill any void space left in the concrete matrix.
2. Backside Grouting: Process in which a drill hole penetrates completely through concrete or structural element and leakage area is sealed with grout from backside, similar to Curtain grouting.
3. Surface Mounted Grouting: Process in which injection ports are installed on exposed surface of concrete defect area and injected from one side.

D. Permeation Grouting: Process of injecting chemical grout under pressure filling the pore space of soil particles in a specified zone of influence; sometimes referred to as soil solidification, backside chemical grouting, curtain grouting, and/or pressure injection.

E. Curtain: A volumetric element (having length, width, and depth) of solidified soil with low permeability qualities and increased compressive strength. Soil pore space shall be filled to 85 percent of its capacity to act as a water impedance grout. Compressive strength increases can range from (10 to 1000) psi depending upon grout chosen.

F. Sleeve Port(s): Injection pipe(s) of various diameters with incremental openings along their length, covered with a rubber gasket; also called manchette tube.

G. Manchette tube: Tube-A-Manchette (TAM) or commonly referred to as Injection Pipe of various diameters with incremental openings along its length, covered with a rubber gasket; also called a sleeve port.

H. Packer(s): Also called a port, sleeve port, injection port or sometimes referred to as a manchette. A mechanical device placed on manchettes and/or in drilled holes in soil or concrete, which grout is pumped into, and forced through; devices shall be chemical resistant HDPE (high density polyethylene), leather or Teflon gaskets, and stainless-steel frame.

I. Slide Packer(s): A mechanical device placed in manchettes with sectionalized inflatable or friction gaskets at each end to distribute pressurized grout to incremental location(s) within the manchette or sleeve port.

J. Injection Head: Mechanical device consisting of a mixing chamber for one or more parts of resin with quick-connects, an on/off switch capability, recirculation, pressure monitoring, and a cleanout; often called an “L”, “E” or “F-Assembly”.

K. Top-down Grouting: Technique whereby grout curtain is established near ground surface and solidified zone proceeds downward.

L. Bottom-up Grouting: Technique whereby grout curtain is established at bottom of manchette and grout zone proceeds upward.

M. Charge and Re-Charge Pipes: Drilled holes for permeation grouting process. Charge holes are pressurized with grout and re-charge holes allow pressure relief and monitoring of grout path and translation; also referred to as “inlet/outlet” ports. Pipes typically installed near water barrier Intersections to control watertightness of individual membrane sections. If leakage should occur, the pipes are used for remedial grouting specifically located at each connection into the terminal; also referred to as “inlet/outlet” ports.

N. Grouting Installation Form: Form provided by Contractor, documenting the location and amount of grout in each manchette location.

O. “Elliptical concrete culvert pipe” may be described as or referred to as a tunnel or simply as a pipe for purposes of this specification.

1.6 SUBMITTALS

A. Shop Drawings: Provide project customized plan, sections and associated details showing the following:
   1. Work scope plan,
   2. Manchette, sleeve port, Inlet/Outlet port, or Charge/Re-charge port locations,
   3. Depth, spacing, and pattern of manchettes,
   4. Details at terminations; interface with existing pipe materials,
   5. Sealing of ports at ground surface,
   6. Grout tube anchorage,
   7. Volumes of grout expected to be pumped per manchette based on the following items noted in the soil investigation and geotechnical report:
      a. Soil strata conditions,
      b. Water table elevations, and
      c. Density and gradations,
   8. Proposed means and methods for Remediation Grouting, if required.

B. Product Data: Injection grout material manufacturer’s literature (catalogue cuts) Including:
   1. Include temperature ranges for storage and application of materials, and special warm/cold-weather application requirements or limitations.
   2. Include recommended Site protection measures.
   3. Include material Safety Data Sheets (SDS) for information only.
   4. Name and contact information for injection-material manufacturer’s Technical Representative that will attend the Pre-installation Meeting.

C. Certificates:
   1. Signed by injection-material manufacturer, certifying that products

furnished comply with requirements and are recommended by manufacturer for uses indicated.

2. Signed by injection-material manufacturer, certifying that individual performing work is approved to install its products.

D. Injection Installer/Subcontractor Qualifications: Provide documentation confirming that the Specialty Contractor is qualified for performing the injection grouting work.

E. Installer/Subcontractor's and/or Manufacturer's field reports.

F. Samples:
1. Reacted Chemical Grout in small plastic bottle; and
2. 24-inch long manchette of proposed diameter for use.

G. Chemical Grouting protection plan/narrative: Describe the intended procedures to prevent damage during construction operations. The following items shall be addressed:
1. Storage set up of equipment; and
2. Handling of drilling fluids if any.

1.7 QUALITY ASSURANCE REQUIREMENTS

A. Pre-installation Meeting:
1. Conduct meeting at Site.
2. Review requirements for injection Work, including:
   a. Safety protocol and tradesmen training,
   b. Construction schedule,
   c. Availability of materials, Injection Installer/Subcontractor's personnel, equipment, and facilities needed to make progress and avoid delays.
   d. Site use, access, staging and set-up location limitations.
   e. Cracks, joints and (M/E/P) to be injected, and condition of other construction that will affect injection Work.
   f. Surface preparation and substrate condition and pretreatment.
   g. Injection procedures.
   h. Testing and inspection requirements.
   i. Site protection measures.
   j. Governing regulations.
3. Contractor's Project Manager and Field Superintendent, injection-material manufacturer's Technical Representative, injection subcontractor's Field Superintendent, OR, and EDR/Grouting Consultant shall attend.

1.8 WEATHER LIMITATIONS

A. Environmental Limitations: Install injection material when existing and forecast weather conditions permit material to be installed and cured according to injection-material manufacturer's written instructions and warranty requirements.
1. Do not install when air and substrate temperatures or humidity are outside limits permitted by injection-material manufacturer.

2. Provide enclosures to protect the work against freezing temperatures, rain, and over exposure to UV light.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials according to manufacturer's recommendations and in such manner as to prevent damage to materials and existing structure.

B. Deliver materials to Site in original containers with seals unbroken, labeled with manufacturer's name; product brand name and type; date of manufacture; lot number; SPI hazardous rating and appropriate warnings for handling; and directions for storing and mixing.

C. Keep materials dry and do not allow materials to be exposed to moisture during transportation, storage, handling and installation. Reject and remove from Site new materials which exhibit evidence of moisture during application or have been exposed to moisture or other deleterious materials.

D. Store materials in original, undamaged containers in clean, dry, protected location on raised platforms with weather-protective coverings, within temperature range required by injection-material manufacturer.

E. Limit stored materials on structures to safe loading capacity of structure at time materials are stored, and to avoid permanent deck deflection.

F. Conspicuously mark damaged or opened containers with contaminated materials, and remove from Site as soon as possible.

G. Remove and replace materials that cannot be installed within stated shelf life.

1.10 PROJECT CONDITIONS

A. Verify existing dimensions and utilities prior to start of injection work. Notify EDR, of conditions found to be different than those indicated in the contract documents.

B. Exercise care to avoid injection or otherwise damaging embedded items. Remove, replace, or otherwise remedy damage to embedded items at no cost to Owner.

C. If unusual or concealed conditions are discovered, stop work and immediately notify EDR in writing.

D. Provide adequate ventilation to ensure no adverse effects from grout fumes, smells, or odors.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Source Limitations: Obtain injection materials through single manufacturer as Much as possible, and/or from sources approved by manufacturer of injection material.

B. Chemical Grout "A" Side by Avanti International, 822 Bay Star Blvd., Webster, TX. 77598 Phone: 800.877.2570 Fax: 281.486.7300:
1. AV-100, Chemical Grout (Granular), plus AV-101 Accelerator,
2. AV-100, Chemical Grout (Liquid), plus AV-101 Accelerator,
3. AV-118, Duriflex Liquid, plus AV-101 Accelerator,
4. AV-160, SuperGel Liquid, plus AV-101 Accelerator, and/or
5. Approved equals from one of the following:
   a. PM-3811 plus Accelerator by Aquafin, Inc.
   b. Gelacyl SR De Neef chemical grout by Grace Construction Products.

C. Chemical Grout "B" Side:
1. AV-102, Catalyst AP, by Avanti International, 822 Bay Star Blvd., Webster, TX. 77598 Phone: 800.877.2570 Fax: 281.486.7300
2. Approved equals from one of the following:
   a. PM-3811 Hardener by Aquafin, Inc.
   c. Gelacyl SR De Neef chemical grout by Grace Construction Products.

D. Auxiliary Materials:
1. Epoxy gel: Use 1 of following or approved equal:
   a. AV-522, by Avanti International, 822 Bay Star Blvd., Webster, TX. 77598 Phone: 800.877.2570 Fax: 281.486.7300
   b. SCB Concresive 1446 manufactured by BASF Construction Chemicals, LLC.
   c. Sikadur 31, Hi-Mod Gel manufactured by Sika Corporation.
2. Hydraulic cement: Use 1 of following or approved equal:
   a. Waterplug manufactured by BASF Construction Chemicals, LLC.
   b. SikaPlug Fast-Setting Water Stop manufactured by Sika Corporation.
3. Plaster-of-Paris or equal for securing and anchoring manchettes.
4. Granular bentonite or equal for securing and anchoring manchettes.
5. Manchettes and/or Sleeve Ports:
   a. PVC, schedule 40 tube or pipe, incremental openings with rubber Gaskets at 15 inches on center by Avanti International or equal.
6. Oakum:
   a. As recommended by the Grout Manufacturer
7. Grouting Equipment and Accessories:
   a. Stainless Steel, 1-to-1 ratio dual piston pump, with pressure Control gauges.
   b. Stainless steel diaphragm pumps for supplying grout to pump from Mixing barrows.
      Stainless steel "E" or "F"-Assembly with check-valves and ball valve Control.
   c. Chemical resistant, insulated injection hose lines for work in cold Weather.
   d. Stainless steel/HDPE Slide Packers, air or friction gaskets.

e. HDPE and stainless-steel mixing barrows and paddles.
f. Stainless steel packers with needle extensions for localized grout Curtain leakage remediation during excavation.
g. Water and/or liquid control meters for grout volume monitoring.

PART 3 - EXECUTION

3.1 GROUTING PHASES AND GENERAL WORK SCOPE

A. Curtain Tunnel Section Grouting shall be performed by one of four procedures, these are as follows:
1. Penetration into soil backfill through existing concrete pipe walls with perforated pipe,
2. Penetration into soil backfill through existing concrete pipe walls with solid pipe and performing top-down grouting,
3. Penetration into soil backfill through existing concrete pipe walls with solid pipe and performing bottom-up grouting, or
4. Surface mounted packer or injection port set into concrete pipe walls allowing for top-down grouting, (basis-for-design).

B. The Contractor shall perform a mock-up at the site to establish/verify injection grout spacing for manchette/packer/port locations. The contractor shall determine which of the four methods, or a combination thereof, that will provide water-and-soil tightness. The mock-up shall provide for the following:
1. Drill hole spacing's for manchettes/packers shall not exceed 1'-4" on center unless it is shown to accomplish design results.
2. Drill hole diameters shall be between 3/8" to ¾" in diameter.
3. Injection grout pressures shall be between 10 and 30 psig.
4. Grout volume shall be determined by translation from port-to-port of injection material and/or approximately 3 gallons per port.

C. First Pass: Inject all manchette/packer/port locations. Label drill holes locations in the field; record drill hole locations on a drawing, the date, quantities of grout injected at each location, and the grout batch number on an Xcel spreadsheet.

D. Second Pass: Repeat injection grouting at any locations if leakage persists. Record the date, quantities of grout injected at each location, and the grout batch number on an Xcel spreadsheet.

E. Remediation Grouting: If excessive groundwater seepage continues to occur after the second pass, consult with OR and EDR.

3.2 EXAMINATION

A. The injection subcontractor's Field Superintendent and injection-material manufacturer's Technical Representative shall:
1. Ensure that work done by other trades is complete and ready for injection grouting.
2. Examine existing substrates and site conditions to confirm compliance with grouting requirements and approved shop drawings.

3. Notify EDR in writing of substrates or conditions that may adversely affect installation or performance of injection grouting and recommend corrections.

B. Do not proceed with injection work until adverse conditions have been corrected and reviewed by EDR.

C. Commencing injection grouting work constitutes acceptance of work surfaces and conditions.

3.3 PROTECTION

A. Protect existing surfaces from Work in progress from mechanical damage due to drilling operations, scaffolding, and/or methods of work and other equipment.

B. Limit access to work areas.

C. Exercise care to avoid injection or otherwise damaging embedded items. Remove, replace, or otherwise remedy damage to embedded items at no cost to Owner.

3.4 PRESSURE INJECTION EQUIPMENT

A. Injection equipment shall be capable of pumping injection material under pressure through manchettes/packers and/or ports; and shall be approved by injection-material manufacturer.

3.5 PREPARATION FOR PERMEATION GROUTING

A. Inspect surfaces and locate areas to be injected.

B. Holes for acrylamide grout shall be same holes as used for hydrophilic urethane grout at concrete pipe joints.

C. Locate steel reinforcing prior to any new or additional drilling.

D. Drill holes for manchettes/packers/ports in accordance with approved shop drawings.

E. Install manchettes/packers/ports to achieve spacing patterns shown on the contract drawings based on mock-up.
1. Drill holes for injection ports or packers at 90-degree angle to surface.
2. After packer is set into place, test hole with pressurized water.
3. If pressurized water leaks through concrete pipe joint, hydrophilic urethane grout has not properly sealed the joint.
4. Reinject that location according to “B-Series” drawings.

3.6 PACKER / PORT / MANCHETTE GROUTING

A. Perform grouting in the presence of the injection-material manufacturer’s Technical Representative. The Technical Representative shall provide

documentation confirming that grouting was installed in accordance with requirements or an explanation why it was not.

B. Maintain conditions and injection material at adequate temperatures for suitable time so that injection material will fill soil voids and achieve full cure.

C. Using the lowest possible pressure to achieve desired result, continuously inject material into manchettes/packers/ports, as recommended by injection-material manufacturer.
   1. Use injection pressure of 10 to 30 pounds per square inch, depending on Manchette/packer/port spacing, width, depth of grouting, and condition(s) of soil.
   2. Start injection at pipe invert or lowest packer elevation and work towards crown; continue until injection material reaches the pre-calculated volumes.
   3. If colored acrylamide grout penetrates the previously injected concrete pipe joint, mark location and resume “Series B” grouting protocol with hydrophilic urethane grout.
   4. Remove injection nozzle or head from packer immediately after injection material reaches the pre-calculated volumes.
   5. Continue injection process bottom-up and from port-to-port, monitoring grout volume at each location.

D. When grouting from port-to-port, if-and-when uncured or un-gelled material comes up adjacent injection hole. Stop injecting for a minute or two until it solidifies, flush static mixer on “E” assembly injection gun.

E. Upon grout solidification of adjacent injection hole, resume grouting operations as per specified quantity of grout.

3.7 CLEANING

A. Protect existing tunnel surface finish(s) from grout stains.

B. Clean surfaces of excess grout, and injection ports or packers.
   1. Allow injection material enough time to cure before performing cleanup.
   2. Clean surfaces by grinding or other means.

C. Plug drill holes with mortar comparable in strength to concrete culvert pipe and top hole with crystalline waterproofing slurry after grouting is complete.

D. Patch holes at injection ports.

PART 4 - CONTRACTOR’S QUALIFICATIONS AND QA/QC REQUIREMENTS

4.1 GENERAL

A. Inspection:
   1. Manufacturer’s representative to inspect completed application and provide a written report that application complies manufacturer’s instructions.

B. Product:
1. Supply and install only products specifically designed and manufactured for this type of construction.
2. Select manufacturers of accessory products who are regularly engaged in the production of similar materials for underground structures.

C. Supervision and Training of Personnel:
1. Execute all installation and testing under the direct supervision of an individual with minimum five (5)-years-experience in the installation of grouting systems for underground structures using injection materials as specified.
2. Provide trained personnel for installation and testing operations.
3. The installer must have a minimum of five (5) years of experience at installation of grouting/injection materials in underground installations.
4. The proficiency of each technician shall be demonstrated in the field for approval by the Contracting Officer's Technical Representative (COTR).
5. The grouting system(s) shall be applied only by an approved contractor authorized by the Manufacturer prior to bid.
6. All work shall be completed by trained and authorized personnel.
7. Installation of grouting/injection system(s) shall be the responsibility of the Grouting Applicator to ensure undivided responsibility.
8. Upon request, the Applicator must submit a list of jobs performed by his employees and supervisors similar to the proposed system being bid.

D. Manufacturer's Performance:
1. Shall have documented experience of a minimum of 10 projects of similar scope.
2. The grouting/injection products are to made by a nationally-recognized manufacturer specializing in water control systems; have been used successfully on projects similar to this; and are appropriate for the substrate, groundwater, hydrostatic pressure, and soil and rock contamination conditions that may be expected in this Contract.

E. Installation Contractor:
1. Installation contractor of grouting materials be certified shall and/or be approved by the manufacturer in writing prior to bid submission.

4.2 FIELD QUALITY CONTROL

A. Installer's quality assurance technician shall be present during grouting work.

B. Provide:
1. Access to Work.
2. Materials for sampling.
3. Site facilities for sampling, testing, and storage of materials.
4. Incidental labor.

C. Sample each batch of material to be injected to determine reaction times:

Obtain 1 sample of injection material prior to beginning injection Work each day, representing first 50 feet of injection, and 1 sample for every 100 feet of injection thereafter. Provide the following:

1. Allow samples to cure. The reaction should start after ± 30 seconds and will end after ± 2:30 minutes.
2. Do not begin injection Work each day until initial sample has satisfactorily cured.
3. Label samples with injection date and location of injected manchette represented by sample.
4. Retain samples in a safe location on site.

D. Monitor and Report:
   1. Ambient temperatures,
   2. Grout consumption per manchette/packer/port,
   3. Equipment pressures, and
   4. Material ratios.

4.3 TESTING AND INSPECTION

A. Permeation Grouting Verification:
   1. After installation of soil permeation grouting, OR and EDR shall conduct visual surveys to determine whether soil-tightness exists at pipe joints.

B. Permeation Grouting Verification by Core Sampling:
   1. At completion of permeation grouting OR and EDR may require contractor at his expense to perform auger core samples of treated soil at its discretion. A minimum of 10 samples at various joint locations will be surveyed. Inconsistent samples shall be re-grouted and then re-sampled at contractor's expense.

C. Sampled cores in the grout curtain shall have permeation grout filling a minimum of 85 percent pore space with gel, depending upon product chosen. Areas of deficient grout in soil pore space matrix shall be drilled and re-grouted at contractor's expense to ensure compliance.

D. Injected permeation grout curtain shall be uniform consistency in soil pore space. Soil or core boring samples taken after permeation grouting is completed showing inconsistent grout matrix shall not constitute satisfactory performance and will not be included in the pay items until drilled and re-grouted to meet compliance.

END OF SECTION 03 64 20

Section 03 64 23 -- Epoxy Resin Crack Injection

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes epoxy resin grout injection through cracks in concrete within the elliptical culvert pipe from 40 mils (1 mm) to 120 mils (3 mm). Epoxy injection is specified to seal against water entry and re-establish concrete structural integrity.

B. Work of this section will be designated on the drawings as WP-6 and is itemized in Scope-of-Work sections on the Construction Documents.

C. Related Sections: Other specification sections, which directly relate to the Work of this Section and include, but are not limited to, the following:
1. Section 03 64 13 Polyurethane Grout, Crack-Joint Injection, WP-1
2. Section 03 64 20 Acrylamide Grout Joint Injection, Soil Solidification, WP- 2
3. Section 03 61 10 Ultra-fine Cement, Soil Stabilization, SS-3
4. Section 07 16 16 Crystalline Waterproofing, WP-4
5. Section 03 64 10 Polyacrylate Grout Crack Injection, WP-5
6. Section 03 64 23 Epoxy Resin Crack Injection, WP-6
7. Section 07 13 56 Thermoplastic Sheet Strip Seals, WP-7

D. Contractor shall be responsible for reviewing site conditions to verify quantities.

E. Contractor shall be responsible for magnitude (depth and width), scope (length) of epoxy resin grouting control as schematically shown and outlined on the contract documents.

F. Contractor shall follow prescriptive requirements of this specification; however, Contractor may modify as necessary the procedures, products, and installation to achieve water control through the leaking concrete culvert pipe if approved via shop drawings.

1.2 SECTION INCLUDES

A. Injection grouting to minimize water leakage post construction and is organized as follows:
1. Examination
2. Preparation and Layout
3. Mounting Injection Ports
4. Air-flushing Injection Ports
5. Setting Injection Ports
6. Injection Grouting Operations
7. Port Removal
8. Clean-up and Demobilization

1.3 REFERENCES

A. Reference Standards: Latest edition as of Specification date.
   1. American Society for Testing and Materials (ASTM) - ASTM International:
      a. ASTM C42/C42M: Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
      b. ASTM C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
      c. ASTM D420: Standard Guide for Investigating and Sampling Soil and Rock.
      d. ASTM D2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
      e. ASTM F2304 Standard Practice for Rehabilitation of Sewers using Chemical Grouting (latest revision).
      f. ASTM F2454 Standard Practice for Sealing Lateral Connections and lines from the mainline Sewer Systems by Lateral Packer Method, Using Chemical Grouting (latest revision).

B. Department of Labor, Occupational Safety and Health Administration (OSHA), Occupational Safety and Health Standards – Excavations, Final Rule – 29 CFR, Part 1926

C. American National Standards Institute (ANSI):
   1. Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD). Z535.1 Safety Color Code

D. American Public Works Association (APWA):
   1. Uniform Color Code for Temporary Marking of Underground Utility Locations.

E. Other Applicable Standards:
   1. API RP 13B-1, Recommended Practice for Field Testing Water-based Drilling Fluids.
   2. National Association of Sewer Service Companies (NASSCO) prepared Pipeline Assessment and Certification Program (PACP), TV inspection form and sewer condition codes.

1.4 ABBREVIATIONS:

A. Commonly used abbreviations used in this specification are as follows:
   1. OR – Owners Representative
   2. CO – Contracting Officer
   3. COR – Contracting Officer’s Representative
   4. COTR – Contracting Officer’s Technical Representative
   5. M/E/P – Mechanical Electrical Plumbing
   6. SPI – Safety Performance Index
   7. EDR – Engineering Design Representative
   8. SDS – Safety Data Sheet
   9. HEPA – High Efficiency Particulate Air
   10. mm – millimeters (40 mils = 1 mm)
   11. mil – millage, 1/1,000 inch = 0.001”
   12. QA – Quality Assurance
   13. QC – Quality Control

14. WP -- Waterproofing
15. SS – Soil Solidification/Stabilization

1.5 DEFINITIONS

A. Specification criteria:
1. Prescriptive based-structural repair/water control criteria established by design professional's details and specifications, or
2. Performance based- structural repair/water control ways-and-means established by contractor and reviewed by design professional.

B. Water leakage nomenclature:
1. Crack Root-The point(s) of water ingress into a concrete element.
2. Crack Mouth- The points of water discharge from a concrete element.
3. Trail- A noticeable pathway/stain on concrete element surface designating continuous water flow.
4. Ponding- The accumulation of water leakage through a concrete element.

C. Five levels of water accumulation on a concrete element can be physically described as follows:
1. Color change (darker), when high moisture content exists at concrete element surface, (white/crystalline or efflorescence) when area has re-sealed itself via autogenous healing), not visually wet to touch, no ponding occurs;
2. Wet to touch, surface dampness in spots, no sustained water trail present, no ponding occurs;
3. Weeps and seepage, sustained trail of wetness, however, visual surface flow not apparent, ponding does occur;
4. Continuous dripping, visual surface flow or water movement over Gushing concrete element, ponding occurs and leaves trail; or
5. flow, from presence of hydrostatic back pressure, ponding leaves continuous trail of water.

D. Water Control: Water control at concrete elements serves many purpose(s):
1. Minimizes potential of dissolved oxygen, carbon dioxide, free chlorides and various salts/contaminants from entering concrete through-wall/floor/elevated-deck cracks and joints.
2. Helps control and potentially mitigate the following:
a) Internal steel reinforcing bar corrosion,
b.) Hardware corrosion of externally attached metal adjacent to wet area
c.) Concrete carbonation, and
d.) Alkali Silica Reactivity and Delayed Ettringite Formation.
e.) Surface delamination of paints, coatings and high build flooring components,
f.) Nutrient Source for mold, algae, and bacterial growth organisms,
g.) Interior surface stains, efflorescence, salt and carbonate buildups (stalactites/stalagmites),
h.) Ice formation (icicles) in unheated enclosures,
I.) Slippery surfaces,

j.) Electrical short circuits, and/or shocks,
k.) Conductor for stray current corrosion,
l.) Potential soil particle loss, and
m.) Costly cleanup when hazardous contaminants (radioactive or poisonous hydrocarbons) enter and accumulate.

E. Structural Parameters: Three important considerations for successful grouting without damaging the structural concrete elements are as follows:
1. Pressures more than 600 psig can cause tensile damage (fracking) to existing concrete elements;
2. Crack width is inversely proportional to pump gauge pressure; and
3. Crack width is proportional to grout viscosity required for proper penetration.

F. Water leakage flow paths:
1. Through-element primary and secondary cracks/joints;
2. Voids and shadows along horizontal or vertical steel reinforcing bar;
3. Unbonded surfaces between concrete and mechanical, electrical, plumbing, penetrations, inserts, or sleeves and dewatering hardware;
4 Poorly consolidated and/or honeycombs within concrete element at
5. Porous foreign objects/debris and/or soil deposits trapped within the concrete element during forming/placement construction and subsequent placement;
6. Through element braided copper ground cables;
7. Form-tie brackets, anchors, wire, or any such temporary or permanent structural inserts.

G. Crack Nomenclature and Width Definitions:
1. Cracks and joints as fine as 1/1000 inch (1 mil) are subject to water leakage if hydrostatic back pressure exists. Water leakage volumes are related to hydrostatic pressure, crack/joint width, and internal friction at crack/joint sidewalls. Cracks and joints are defined as follows:
a. ultra-fine crack/joint (01 to 05) mils (0.025 to 0.127) mm
b. very-fine crack/joint (06 to 10) mils (0.152 to 0.254) mm
c. fine crack/joint (11 to 15) mils (0.279 to 0.381) mm
d. medium-fine crack/joint (16 to 20) mils (0.406 to 0.508) mm
e. medium crack/joint (21 to 40) mils (0.533 to 1.016) mm
f. medium-wide crack/joint (41 to 60) mils (1.041 to 1.524) mm
g. wide crack/joint (61 to 120) mils (1.549 to 3.048) mm

H. Grout(s): Generic term describing various - structural and/or non-structural, cementitious and/or non-cementitious materials which are installed as a liquid, paste or gel/mastic; which may cure-out as a product that exhibits a high or low modulus resulting in an elastic/plastic foam, gel, or paste-like matrix. Injection or placement materials include Portland cement (Types I, II, III, IV, or V, with or without fine aggregate, neat cement as micro-fine and ultra-fine in particle size) and/or bentonite powder blends, potassium/sodium silicates, reactive polymer(s), such as urethane (hydrophobic/hydrophilic), epoxy, methyl-methacrylate, acrylamide and polyacrylate resins, solvent (hydrocarbon or water) based rubber gels, and hot/cold asphalt fluids and/or emulsions. Grout viscosity has a relationship with pumping pressure and crack width, among other parameters

such as temperature, cross-sectional width of voids, gel-time, and water chemistry. Four grout designations are as follows:

1. Low viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material when initially mixed facilitates a viscosity of (1 to 15) centipoise. Said grouts under controlled pressure penetrate ultra-fine cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.
2. Medium viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material when initially mixed facilitates a viscosity of (50 to 100) centipoise. Said grouts under controlled pressure penetrate fine cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.
3. High viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material when initially mixed facilitates a viscosity of (500 to1,000) centipoise. Said grouts under controlled pressure penetrate medium-wide cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.
4. Very-high viscosity chemical grout: A three-, two-, or one-part reactive resinous polymer material or non-reactive fluid when initially mixed facilitates a viscosity of (2,000 or greater) centipoise. Said grouts under controlled pressure penetrate wide cracks/joints in concrete elements with minimal secondary fracking; sets-up (cures) to a flexible or rigid, resin, gel or foam consistency.

I. Grouting Types and Procedures:
   1. Interception Grouting: Process by which a crack or joint is intercepted between its mouth and root (origin), and further a chemical grout is pumped into it under gauge pressure to fill any void space left in the concrete matrix.
   2. Backside Grouting: Process in which a drill hole penetrates completely through concrete or structural element and leakage area is sealed with grout from backside, similar to Curtain grouting.
   3. Surface Mounted Grouting: Process in which injection ports are installed on exposed surface of concrete defect area and injected from one side.

J Permeation Grouting: Process of injecting chemical grout under pressure filling the pore space of soil particles in a specified zone of influence; also referred to as soil solidification, chemical grouting, curtain grouting, and/or pressure injection.

K. Grout Curtain: A solidified soil element (of length, width, and depth) having low permeability qualities.

L. Sectioning: Grout curtain in soil strata arranged to seal off individual structural sections. Used in connection with “charge” and “re-charge” grouting pipes to create a grout curtain system, which promotes control of watertightness and facilitates leakage remediation.

M. Charge and Re-Charge Pipes: Drilled holes for permeation grouting process. Charge holes are pressurized with grout and re-charge holes allow pressure

relief and monitoring of grout path; also referred to as “inlet/outlet” ports.

N. Control and Grouting Pipes: Pipes typically installed near water barrier intersections to control water-tightness of individual waterproof membrane sections. If leakage should occur, the pipes are used for remedial grouting specifically located at each connection or interruptions to concrete pours; also referred to as “inlet/outlet” ports.

O. Sleeve Port(s): Injection pipe(s) of various diameters with incremental openings (perforated pipe) along its length, covered with a rubber gasket; also called manchette tube or Tube-A-Manchette (TAM).

P. Manchette tube: Tube-A-Manchette (TAM) or commonly referred to as Injection pipe(s) of various diameters with incremental openings along its length, covered with a rubber gasket; also called a sleeve port.

Q. Packer(s): A mechanical device placed into or through drilled holes in concrete elements or driven into soil, through which grout is pumped into, and forced through; also referred to as injection port, expandable packer, or wall sphere. Devices shall be chemical resistant HDPE (high density polyethylene), neoprene rubber, leather or Teflon gaskets, and stainless-steel, brass, aluminum, or carbon steel frame. Most contain a grease zerk, button head, or quick-connect for attachment to the Injection head.

R. Slide Packer(s): A mechanical device placed into plastic manchettes with sectionalized inflatable or friction gaskets (leather or Teflon) at each end to control and distribute pressurized grout to incremental location(s) within the manchette or sleeve port.

S. Injection Head or Gun: Mechanical device consisting of a mixing chamber for one or more parts of resin with quick-connects, zerk grease fitting, button head, and an on/off switch or ball-valve to control flow and capability, recirculation, pressure monitoring, and a cleanout; often called an “E” or “F”-Assembly.

U. Crystalline Waterproofing Mortar: Portland cement/silica sand mortar with reactive chemical admixture that promotes crystalline growth in the reinforced element. Reactive chemicals combine the free calcium hydroxide in concrete to crystallize and imped water flow.

V. Grouting Procedures:
1. Top-down Grouting: Injection technique whereby grout curtain is established near ground or exposed surface, once that solidifies, manchettes are drilled through the solidified zone and grouting proceeds sequentially downward.
2. Bottom-up Grouting: Technique whereby grout curtain is established at bottom of hole and manchettes are sequentially lifted and grout zone proceeds upward.

W. Grouting Installation Form: Form provided by Contractor, documenting the location and amount of grout in each manchette location.

X. Dual and Single Component Pump(s): Operated with compressed air, electric, hydraulic oil, or mechanically operated pump with single mechanism or multi-ratio mechanisms for pumping various grout components.

Y. Quality Control: A system for verifying and maintaining a desired level of quality in an existing product or service by careful planning, use of proper equipment, continued inspection, and corrective action as required.

Z. Quality Assurance: A systematic monitoring and evaluation program for various aspects of a project, service, or facility to ensure that standards of quality are being met.

1.6 SUBMITTALS

A. Shop Drawings: Provide project customized plan, sections and associated details showing the following:
1. Work scope plan if different from contract documents.

B. Product Data: Injection grout material manufacturer's literature (catalogue cuts) including;
1. Written instructions for handling, mixing, and safety procedures.
2. Technical data including tested physical and performance properties, including:
   a. Temperature ranges for storage and application of materials, and special warm/cold-weather application requirements or limitations,
   b. Include recommended Site protection measures, and
   c. Safety Data sheets.

C. Certificates:
1. Signed by injection-material manufacturer, certifying that products furnished comply with requirements and are recommended by manufacturer for uses indicated.
2. Signed by injection-material manufacturer, certifying that individual(s) performing work is approved to install its products.

D. Injection Installer/Subcontractor Qualifications: Evidence that Subcontractor's existing company has minimum 5 years of continuous experience in injection of specified materials; list of at least 5 representatives, successfully completed projects of similar scope and size, including:
1. Project name.
2. Owner's name.
3. Owner's Representative name, address, and telephone number.
4. Description of work.
5. Injection materials used.
6. Equipment used.
7. Project supervisor.
8. Total cost of injection work and total cost of project.
9. Completion date.

E. Installer/Subcontractor's and/or Manufacturer's field reports.

F. Resume' of epoxy grouting installation supervisor.

G. Samples: Reacted epoxy grout in small plastic bottle.

H. Epoxy Grouting protection plan/narrative: Describe the intended procedures to prevent damage during construction operations. The following items shall be addressed:
1. Storage and set up of equipment;
2. Restoration of drill holes;
3. Steel reinforcing location plan;
4. Handling of drilling fluids and waste products if any; and
5. Testing to ensure continuous and monolithic grout pattern.

1.7 QUALITY ASSURANCE REQUIREMENTS

A. Personnel identified during prequalification process shall be the personnel conducting the Work.

B. Pre-installation Meeting:
1. Conduct meeting at Site.
2. Review requirements for injection Work, including:
   a. Safety protocol and tradesmen training,
   b. Construction schedule,
   c. Availability of materials, Injection Installer/Subcontractor's personnel, equipment, and facilities needed to make progress and avoid delays.
   d. Site use, access, staging and set-up location/limitations.
   e. Cracks and joints to be injected, and condition of other construction activity that will affect injection Work.
   f. Injection procedures.
   g. Testing and inspection requirements.
   h. Site protection measures.
   i. Governing regulations.

C. Contractor's Site superintendent, injection-material manufacturer's technical representative, Injection Subcontractor's foreman, COR, COR's Representative, and Grouting Consultant, shall attend.

1.8 WEATHER LIMITATIONS

A. Environmental Limitations: Install injection material when existing and forecast weather conditions permit material to be installed and cured according to injection-material manufacturer's written instructions and warranty requirements.

B. Do not install when air and substrate temperatures are outside limits permitted by injection-material manufacturer. Provide enclosures to ensure against freezing temperatures and or over exposure to UV light, unless approved in writing by injection-material manufacturer.

C. Contractor/Grouting Installer shall be aware that un-managed water can be a safety issue.

D. Do not work in severe temperatures, moisture, and excessive humidity; these may affect the installation and performance of products during construction. Consult with Manufacturer's Representative and comply with applicable material recommendations for workmanship and handling.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials according to manufacturer's recommendations and in such manner as to prevent damage to materials and existing structure.

B. Deliver materials to Site in original containers with seals unbroken, labeled with manufacturer's name; product brand name and type; date of manufacture; lot number; SPI hazardous rating and appropriate warnings for handling; and directions for storing and mixing.

C. Keep materials dry and do not allow materials to be exposed to moisture during transportation, storage, handling and installation. Reject and remove from Site new materials which exhibit evidence of moisture reaction during application or have been exposed to abuse or other deleterious materials.

D. Store materials in original, undamaged containers in clean, dry, protected location on raised platforms with weather-protective coverings, within temperature range required by injection-material manufacturer.

E. Limit stored materials on structures to safe loading capacity of structure at time materials are stored, and to avoid permanent deck deflection.

F. Conspicuously mark damaged or opened containers with contaminated materials, and remove from Site as soon as possible. Dispose containers to legal dump site.

G. Remove and replace materials that cannot be installed within stated shelf life.

1.10 PROJECT CONDITIONS AND SAFETY PROTOCOL

A. Verify existing dimensions and any known utilities (buried drainpipes, electrical or telecom service) prior to start of injection Work. Notify COR, if conditions found to be different than those indicated in Contract Documents. Be aware of buried utilities, (drainpipes, electrical or telecom service) unknown at time of drilling.

B. If unusual or concealed conditions are discovered, stop work and immediately notify COR in writing. Be aware of private drain line pipes and fields.

C. Provide adequate ventilation and protect adjacent building air intakes (if any) to ensure no adverse effects from grout fumes, smells or odors. Note the following:
   1. Acrylic grout oxidizers give off an ammonia smell/vapor;
   2. Urethane grouts give off MDI or TDI smell/vapors;
   3. Epoxy grouts can give off hydrocarbon smells.

4. Carbon dioxide is released as part of polyurea/polyurethane reaction:
5. Hot asphalt can give off benzene vapors and hydrocarbon smells;
6. Bentonite and cement grouts give off silica dust when mixing with water;
7. Hydrocarbon solvents are released when used as a viscosity reducer;
8. Drilling into concrete produces silica dust; and
9. Adding ethylene glycol to air intake lines of grout pump can produce air-borne hydrocarbons in the immediate area.

D. Follow OSHA regulations during work performance, and particularly when the following occurs:
1. Trades people are working on platforms and scaffolding;
2. Heights more than four feet;
3. When using ladders;
4. When drilling into concrete and creating sparks and dust;
5. Use OSHA approved HEPA dust collection systems when drilling into concrete elements;
6. Wear goggles, face shields, or similar when high grout pressures are used;
7. Wear proper PPE clothing and gloves when handling solvent, hot, and/or reactive chemicals.

PART 2 – MATERIALS

2.1 PRODUCTS

A. Source Limitations: Obtain injection materials through single manufacturer as much as possible, and/or from sources approved by manufacturer of injection material.

B. Approved Products and Chemical Grout Manufacturers/Suppliers:
1. Sikadur 32 or 52, Injection Adhesive manufactured by Sika Corporation.
2. AV-502 LV or AV-502 HV by Avanti International, 822 Bay Star Blvd., Webster TX. 77598 Phone: 800-877-2570 Fax: 281-486-7300

C. Or-equal grout manufacturer. Products shown to be equal in viscosity, solids percentage in acrylic resin component, chemical composition, and performance are of consideration by Specifying Engineer. Approved equal products must be approved in writing prior to bid proposal.

D. Auxiliary Materials:
1. Epoxy gel: Use 1 of following or approved equal:
   a. AV-520 by Avanti International, 822 Bay Star Blvd., Webster TX. 77598 Phone: 800-877-2570 Fax: 281-486-7300
   b. SCB Concresive 1446 manufactured by BASF Construction Chemicals, LLC.
   c. Sikadur 31, Hi-Mod Gel manufactured by Sika Corporation.
2. Hydraulic cement: Use one of following or approved equal:
   a. Aquafin-Plug-IC, manufactured by Aquafin Inc.
   b. Water plug manufactured by BASF Construction Chemicals, LLC. SikaPlug Fast-Setting Water Stop manufactured by Sika Corporation.

3. Oakum:
   a. As recommended by the Grout Manufacturer.
4. Grouting Equipment and Accessories:
   a. Stainless Steel or equal, 1-to-1 ratio, dual piston pump, with pressure control gauges for epoxy or urethane grouts.
   b. Chemical resistant, insulated injection hose lines for work in cold or hot weather.
   c. Plastic ports for surface mounted injection.
   d. Water and/or liquid control meters for grout volume monitoring.

PART 3 - EXECUTION

3.1 GROUTING PHASES AND GENERAL WORK SCOPE

A. Perform injection grouting operations at locations shown on the contract documents. Inject cracks and joints in heavily reinforced concrete that exhibits structural damage or water leakage.

B. Perform injection grouting all concrete crack and joint areas. Label locations using submitted and approved shop drawing(s). Identify locations and quantities of grout injected at each drilled port.

C. Final Inspection: The final inspection shall be performed after injection is completed. Submit to Owner, recovery plan for leakage control if said leakage persists after third pass.

3.2 EXAMINATION

A. Injection Subcontractor to examine substrates and conditions with, COR representative and injection-material manufacturer for compliance with requirements and for other conditions affecting installation or performance of structural and water control Work.
   1. Examine crack and joint widths for determination of which grout types have the appropriate viscosity and will minimize injection pressures and fracking.
   2. Injection pressure limited to bond strength of epoxy paste on surface of crack.
   3. Ensure that work done by other trades is complete and ready for Injection work. If mechanical or electrical equipment or other obstructions block crack and/or joint access, discuss plan to achieve structural and/or water control goals.
   4. Verify that areas and conditions with Injection Subcontractor and representative of injection material manufacturer for compliance with requirements and for other conditions affecting installation or performance of structural or water control Work.
      Notify COR, in writing of conditions which may adversely affect installation or performance of injection Work and recommend corrections.
   5. Do not proceed with injection Work until adverse conditions have been corrected and reviewed by COR, and Grouting Consultant (if any).
   6. Commencing injection Work constitutes acceptance of Work surfaces and conditions.

3.3 PROTECTION

A. Protect existing surfaces from injection Work in progress and from mechanical damage due to drilling operations, scaffolding, and/or methods of work and other equipment.

B. Limit access to Work areas. Always wear PPE equipment when using fluids and air under pressure. Wear gloves to avoid skin contact with unreacted grouts. Follow all OSHA and Site Safety protocols.

C. Exercise care to avoid injection or otherwise damaging embedded items. Remove or replace or otherwise remedy damage to embedded items, at no cost to Owner.

3.4 PRESSURIZED INJECTION EQUIPMENT AND PRETESTING

A. Injection equipment shall be capable of pumping injection material under pressure through properly rated hoses and injection ports; equipment shall be approved by injection-material manufacturer.

B. Mark grout component pails and pump intake/discharge lines with colored coded tape, colored lines, or designate components of part “A” resins from part “B” resins. Separate mixing devices such that no cross-contamination exists.

C. Perform ratio check on part “A” and part “B” lines prior to any grouting; confer with manufacturer for approval if any ratios are not as specified. Adjust per manufacturer’s instructions and note items on shop drawings.

D. Perform reaction time test by mixing part “A” to part “B” resins and noting initial set and viscosity change of mixed grout, document on shop drawings.

3.5 PREPARATION FOR INTERCEPTION GROUTING

A. Inspect surfaces and locate areas to be injected. Locate steel bar in concrete elements prior to drilling. Survey for suspected utility or electrical lines in concrete.

B. Install surface mounted ports to achieve spacing pattern as shown by approved shop drawings and provide the following:
   1. Number, spacing, and location of ports shall be as submitted in the approved shop drawings with noted tolerance.

3.6 SURFACE MOUNTED VALVE PACKERS

A. Perform grouting Work in presence of representative of injection-material manufacturer. At conclusion of Work, manufacturer’s representative shall prepare and furnish letter or report to COR, stating whether installation was completed in accordance with requirements. These manufacturer’s services shall be provided at no additional cost to Owner.

B. Mix chemical grout components per manufacturers requirements in separate and clean pails. Place dams and spill containment under pump and mixed grout pails. Add colorants or dyes to grout for identification purposes, if desired.

C. Maintain conditions and injection material at adequate temperature for suitable time so that injection material will completely fill the drill hole and void and will achieve full cure.

D. Using the lowest possible pump pressure to achieve desired result, continuously inject material into packers to avoid fracking the concrete element, and as recommended by injection-material manufacturer.
   1. Start injection at lowest packer elevation and move to higher elevations, continue until injection material reaches the pre-calculated volumes and flows from the mouth of crack or joint.
   2. Use injection pressure of 10 to 50 psi (pounds per square inch), depending on port spacing, width of crack, depth of grouting, and condition(s) of concrete. Increase pressure in 10 psi increments to achieve grout flow.
   3. Continue injection process from port to port, monitoring grout volume and ensure grout pump pressures do not exceed 600 psig.
   4. Immediately after second “Second Pass” of grouting, inject water in controlled fashion to flush out injection port.
   5. Remove injection head after injection material initially sets and reaches the pre-calculated volumes per port and has cured.

3.7 SHUT-DOWN AND PUMP FLUSHING

A. Upon completion of injection protocol including passes 1 and 2, remove intake lines from grout pails and flush pump with manufacturers approved, solvent, flushing agent. Flushing agent may be water in some cases.

B. Upon completion of pump flushing, fill lines and cylinders with manufacturers approved lubrication and corrosion resistant medium.

C. Remove reacted chemicals and waste flushing agents from the site and dispose at appropriate land fill.

3.8 DRILL HOLE RESTORATION

A. Upon completion of drill hole injection protocol including passes 1 and 2, remove ports/packers, if not done previously, from injected crack or joint locations. Ensure all grout has fully cured prior to packer removal.

B. Clean surface of injected crack and/or joint prior to demobilization. Remove reacted chemicals and waste flushing agents from the site and dispose of debris off site to a legal dump facility.

3.9 CLEANING

A. Protect existing building surface finish(s) from grout stains.

B. Clean surfaces of excess grout, and injection ports or packers.
1. Allow injection material enough time to cure before performing cleanup.
2. Clean surfaces by grinding or other means.
3. Ensure all holes are patched at injection ports.

PART 4 - CONTRACTOR'S QUALIFICATIONS AND QA/QC REQUIREMENTS

4.1 GENERAL

A. Inspection:
1. Manufacturer's representative to inspect completed application and provide a written report that application complies manufacturer's instructions.

B. Product:
1. Supply and install only products specifically designed and manufactured for this type of construction.
2. Select manufacturers of accessory products who are regularly engaged in the production of similar materials for underground structures.

C. Supervision and Training of Personnel:
1. Execute all installation and testing under the direct supervision of an individual with minimum five (5)-years-experience in the installation of grouting systems for underground structures using injection materials as specified.
2. Provide trained personnel for installation and testing operations.
3. The installer must have a minimum of five (5) years of experience at installation of grouting/injection materials in underground installations.
4. The proficiency of each technician shall be demonstrated in the field for approval by the Contracting Officer's Technical Representative (COTR).
5. The grouting system(s) shall be applied only by an approved contractor authorized by the Manufacturer prior to bid.
6. All work shall be completed by trained and authorized personnel.
7. Installation of grouting/injection system(s) shall be the responsibility of the Grouting Applicator to ensure undivided responsibility.
8. Upon request, the Applicator must submit a list of jobs performed by his employees and supervisors similar to the proposed system being bid.

D. Manufacturer's Performance:
1. Shall have documented experience of a minimum of 100,000 square feet or similar.
2. The grouting/injection products are to made by a nationally-recognized manufacturer specializing in water control systems; have been used successfully on projects similar to this; and are appropriate for the substrate, groundwater, hydrostatic pressure, and soil and rock contamination conditions that may be expected in this Contract.

E. Installation Contractor:

1. Installation contractor of grouting materials be certified shall and/or be approved by the manufacturer in writing prior to bid submission.

4.2 FIELD QUALITY CONTROL

A. Installer's quality assurance technician shall be present during grouting work.

B. Provide:
1. Access to Work.
2. Materials for sampling.
3. Site facilities for sampling, testing, and storage of materials.
4. Incidental labor.

C. Sample each batch of material to be injected to determine reaction times: Obtain 1 sample of the injection material prior to beginning injection Work each day, representing first 50 feet of injection, and 1 sample for every 30 feet of injection thereafter. Provide the following:
1. Allow samples to cure. The reaction should start after ±10 minutes and end after 2 hours.
2. Do not begin injection Work each day until initial sample has satisfactorily cured.
3. Label samples with injection date and location of injected packer represented by sample.
4. Retain samples in a safe location on site.

D. Monitor and Report:
1. Ambient temperatures;
2. Grout consumption per packer;
3. Equipment pressures; and
4. Material ratios.

END OF SECTION 03 64 23

Section 07 13 56 -- Thermoplastic Sheet Strip Seals

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes thermoplastic strip seal waterproofing for interior pipe culvert in widths greater than 1.50 inches or where defects exist.

B. Work of this section will be designated on the drawings as WP-7 and is itemized in the Scope-of-Work sections on the Construction Documents.

C. Related Sections: Other specification sections, which directly relate to the Work of this Section and include, but are not limited to, the following:
1. Section 03 64 13 Polyurethane Grout, Crack/Joint Injection, WP-1
2. Section 03 64 20 Acrylamide Grout Joint Injection, Soil Solidification, WP- 2
3. Section 03 61 10 Ultra-fine Cement, Soil Stabilization, SS-3
4. Section 07 16 16 Crystalline Waterproofing, WP-4
5. Section 03 64 10 Polyacrylate Grout Crack Injection, WP-5
6. Section 03 64 23 Epoxy Resin Crack Injection, WP-6
7. Section 07 13 56 Thermoplastic Sheet Strip Seals, WP-7

D. Contractor shall be responsible for reviewing site conditions to verify quantities.

E. Contractor shall be responsible for magnitude (depth and width), scope (length) of joint strip seals as schematically shown and outlined on the contract documents.

F. Contractor shall follow prescriptive requirements of this specification; however, Contractor may modify as necessary the procedures, products, and installation to achieve water control through the leaking concrete culvert pipe joints if approved via shop drawings.

1.2 SUBMITTALS

A. All items listed below shall be submitted altogether, in one set, to form a complete design review package. Approval of Work scope shop drawings by the COTR shall not relieve installation contractor of specified Work in this section, which may have been missing on the approved shop drawings.

B. Shop Drawings shall be submitted to COTR for approval prior to start of work. Prepare and provide standard, project customized details at a scale appropriate for understanding layering, terminations, anchorage, overlaps and embedment's. Do not proceed with WP-7 waterproofing installation without approved shop drawings. Submit drawings of Work Scope in plan and sections, in addition all penetration(s), anchorage and special details of the following:
1. Sequence of waterproofing installation relative to construction sequence, including detailed installation procedure and system tie-ins to other systems when required.
2. Build-up of layered waterproofing at cracks and/or joints.

C. Product Data: Include material descriptions, 8” x 8” samples, SDS, technical data sheets, and installation instructions for crystalline waterproofing. Include the following:
   1. 60-mil membrane sheet,
   2. Epoxy Adhesive,
   3. Stainless steel anchors,
   4. Termination bar, and
   5. Sample Panel 8”x 8” represents WP-7 as entire system with each layer visible and labeled.

D. Qualification Data: For Installer.

E. Manufacturer’s inspection reports of completed installation.

F. Minutes of preinstallation conference.

1.3 REFERENCES

A. Reference Standards: Latest edition as of Specification date.
   1. American Society for Testing and Materials (ASTM) - ASTM International:
      a. ASTM C507 Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
      b. ASTM C1840 Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain and Storm Sewer Pipe.
      c. ASTM C42/C42M: Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
      d. ASTM C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
      e. ASTM D2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
      f. ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
      g. ASTM A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
      h. ASTM C33, Standard Specification for Concrete Aggregate
      i. ASTM 050, Standard Specification for Portland Cement.
      j. ASTM C940, Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory.
      k. ASTM D1785, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
      l. ASTM D2241, Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
      m. ASTM F2304 Standard Practice for Rehabilitation of Sewers using Chemical Grouting (latest revision).
      n. ASTM F2454 Standard Practice for Sealing Lateral Connections and lines from the mainline Sewer Systems by Lateral Packer Method, Using Chemical Grouting (latest revision).

o. ASTM 091, Standard Test Methods for Time of Setting of Hydraulic Cement by VI cat Needle.

B. State of Wisconsin Department of Transportation (Wis-Dot):
1. Standard Specification for Construction.
2. Standard Specifications for Construction of storm sewer and drainage structures.

C. Department of Labor, Occupational Safety and Health Administration (OSHA):
1. Occupational Safety and Health Standards – Excavations, Final Rule – 29 CFR, Part 1926.

D. American National Standards Institute (ANSI):
1. Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD), Z535.1 Safety Color Code
2. ANSI/NSF 61, Drinking Water System Components – Health Effects.

E. American Public Works Association (APWA):
1. Uniform Color Code for Temporary Marking of Underground Utility Locations.

F. Other Applicable Standards:
1. API RP 13B-1, Recommended Practice for Field Testing Water-based Drilling Fluids.
2. National Association of Sewer Service Companies (NASSCO) prepared Pipeline Assessment and Certification Program (PACP), TV inspection form and sewer condition codes.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer. Workers shall have not less than 5 years documented, successful experience with waterproofing work comparable to Work on this Project.

B. Preinstallation Conference: Conduct conference at Project site and document all discussions and agreements.

1.5 PROJECT CONDITIONS

A. Weather Limitations: Proceed with application only when existing and forecasted weather conditions permit crystalline waterproofing to be performed according to manufacturer's written instructions and warranty requirements.

B. Ambient Conditions: Proceed with WP-7 waterproofing work only if temperature is maintained at 40 degrees F or above during work and cure period, and space is well ventilated and kept free of water.

C. Proceed with WP-7 waterproofing work only after all other grouting and waterproofing has been completed. Further proceed only after concrete substrate defects, including honeycombs, voids, and cracks, have been repaired to provide a sound substrate free of soil debris and water.

1.6 MOCK-UP

A. Prior to application of specified WP-7 membrane/coating/slurry, and after approval of shop drawings, erect sample panel on site for mock-up using materials and joint details required for final work. Build mock-up at the site, where directed by COTR, of full thickness indicating the proposed color, texture, and workmanship to be expected in the completed work. Obtain COTR's acceptance of visual qualities of the mock-up before start of Work.

PART 2 – PRODUCTS

2.1 MANUFACTURERS.

A. Available Products: Subject to compliance with requirements, products for PVC sheet waterproofing that may be incorporated into the Work include, but are not limited to, the following:
1. Cooley Engineered Membranes Cooley, Inc.
2. Seaman's Corporation.
3. Sarnafil, Inc.
4. Contractor Option to provide Interior Joint Seals by one of the following:
a. HydraTite Joint System, from
1. HydraTech Engineered Products, LLC
10448 Chester Rd.
Cincinnati, OH 45215
Phone (513) 827-9169
www.hydratechllc.com
b. "Or Equal" interior are acceptable

2.2 MATERIALS

A. Elvaloy PVC Sheet Membranes:
1. Coolguard MPK (60-mil) KEE-Elvaloy Terpolymer Sheet, reinforced with a polyester scrim.
2. Fibertite XTreme (60-mil) KEE-Elvaloy Terpolymer Sheet, reinforced with a polyester scrim.

B. Epoxy Adhesive/gel: Use 1 of following or approved equal:
a. AV-520 by Avanti International, 822 Bay Star Blvd., Webster TX. 77598 Phone: 800-877-2570 Fax: 281-486-7300
b. SCB Concresive 1446 manufactured by BASF Construction Chemicals, LLC.
c. Sikadur 31, Hi-Mod Gel manufactured by Sika Corporation.

C. Termination Bar:
1. Termination Bar: 14-gauge by 25-mm (1-inch) wide channel profiled stainless steel bar, pre-punched 100-mm (4-inches) on-center.

D. Anchors:

1. Fasteners and other hardware shall be stainless steel conforming to ASTM F 593; 6-mm x 38-mm (1/4-inch by 1-½ inch) nylon anchors with stainless steel pins.
2. Bonded neoprene washers or other device acceptable to the COTR, capable of ensuring the prevention of intrusion of water under hydrostatic pressure along the fasteners.

E. Weld-Strip: As supplied by Manufacturer for hot-air welding to vertical thermoplastic waterproofing membrane.

F. Grid Adhesive: 100% solids, two-part urethane, with minimum tensile strength of 150-psi (ASTM D 412) and adhesion to concrete of 12-psi (ASTM D 429). Trowel grade. Grid adhesive is available in both vertical and horizontal grade viscosity.

G. Stainless Steel Band (Hose Clamp), Stainless steel, for use at pipe or conduit penetrations.

H. Membrane Cleaner: Recommended solvent cleaner by Manufacturer.

I. Welder:
1. Hand-held hot-air welding apparatus for flashing of sheets and sheet anchorage and seaming.

J. Sheet Metal Flashing: Provide 20-gauge, stainless steel.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Acceptance of Conditions: Examine substrates, with Applicator present, where waterproofing is to be applied.
1. Proceed with application only after unsatisfactory conditions have been corrected.
2. Notify COTR in writing of active leaks or structural defects that would affect system performance.

3.2 PREPARATION

A. Protect other work from damage from cleaning, preparation, and application of membrane waterproofing.

B. Repair damaged or unsatisfactory concrete according to manufacturer’s written instructions.

C. Surface Preparation: Comply with waterproofing manufacturer’s written instructions to remove efflorescence, chalk, dust, dirt/soil, mortar spatter, grease, oils, curing compounds, and form-release agents to ensure that waterproofing bonds to concrete surfaces.

1. Clean concrete surfaces according to ASTM D 4258. Prepare smooth-formed and trowel-finished concrete by mechanical abrading or abrasive-last cleaning according to ASTM D 4259.
2. Concrete Joints: Clean reveals according to waterproofing manufacturer's written instructions.

3.3 APPLICATION

A. General: Comply with waterproofing manufacturer's written instructions for application.
1. Clean and roughen concrete surfaces prior to placing epoxy adhesive.
2. Apply waterproofing membrane over epoxy adhesive.
3. Allow epoxy adhesive to cure and adhere membrane.
4. Weld membrane overlap near crown of tunnel.
5. Drill anchors through membrane and into concrete substrate.
6. Place anchors secure bar.

3.4 PROTECTION

A. Protect membrane waterproofing from severe weather exposure until it has cured, and from water accumulation. Maintain completed Work in dry conditions for not less than three days by procedures recommended in writing by waterproofing manufacturer. Protect waterproofing from temperatures below 36 deg F.

PART 4 - CONTRACTOR'S QUALIFICATIONS AND QA/QC REQUIREMENTS

4.1 GENERAL

A. Inspection:
1. Manufacturer's representative to inspect completed application and provide a written report that application complies manufacturer's instructions.

B. Product:
1. Supply and install only products specifically designed and manufactured for this type of construction.
2. Select manufacturers of accessory products who are regularly engaged in the production of similar materials for underground structures.

C. Supervision and Training of Personnel:
1. Execute all installation and testing under the direct supervision of an individual with minimum five (5)-years-experience in the installation of waterproofing systems for underground structures using membrane materials as specified.
2. Provide trained personnel for installation and testing operations.
3. The installer must have a minimum of five (5) years of experience in the installation of membranes/coatings in underground waterproofing installations.

4. The proficiency of each technician shall be demonstrated in the field for approval by the Contracting Officer's Technical Representative (COTR).
5. The waterproofing system shall be applied only by an approved contractor authorized by the Manufacturer prior to bid.
6. All work shall be completed by trained and authorized personnel.
7. Installation of waterproofing system shall be the responsibility of the Membrane Applicator to ensure undivided responsibility.
8. Upon request, the Applicator must submit a list of jobs performed by his employees and supervisors similar to the proposed system being bid.

D. Manufacturer's Performance:
1. Shall have documented experience of a minimum of 100,000 square feet.
2. The waterproofing products are to made by a nationally-recognized manufacturer specializing in waterproofing systems; have been used successfully on projects similar to this; and are appropriate for the substrate, groundwater, hydrostatic pressure, and soil and rock contamination conditions that may be expected in this Contract.

E. Installation Contractor:
1. Installation contractor of waterproofing and grouting materials shall be certified and/or approved by the manufacturer in writing prior to bid submission.

END OF SECTION 07 13 56

Section 07 16 16 -- Crystalline Waterproofing

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes crystalline waterproofing for interior pipe culvert substrates) on concrete faces where cracks in width are less than 0.021 inches (21-mils) and/or where surface defects exist.

B. Work of this section will be designated on the drawings as WP-4. Areas receiving this treatment are noted in the Scope-of-Work section of Construction Documents. Contractor has option to treat bottom section of tunnel/pipe 62 inches each side of invert.

C. Related Sections: Other specification sections, which directly relate to the Work of this Section and include, but are not limited to, the following:
1. Section 03 64 13 Polyurethane Grout, Crack/Joint Injection, WP-1
2. Section 03 64 20 Acrylamide Grout Joint Injection, Soil Solidification, WP- 2
3. Section 03 61 10 Ultra-fine Cement, Soil Stabilization, SS-3
4. Section 07 16 16 Crystalline Waterproofing, WP-4
5. Section 03 64 10 Polyacrylate Grout Crack Injection, WP-5
6. Section 03 64 23 Epoxy Resin Crack Injection, WP-6
7. Section 07 13 56 Thermoplastic Sheet Strip Seals, WP-7

D. Contractor shall be responsible for reviewing site conditions to verify quantities.

E. Contractor shall be responsible for magnitude (depth and width), scope (length) of permeation grouting control as schematically shown and outlined on the contract documents.

F. Contractor shall follow prescriptive requirements of this specification; however, Contractor may modify as necessary the procedures, products, and installation to achieve water and sand control through leaking concrete culvert pipe joints and cracks if approved via shop drawings.

1.2 SUBMITTALS

A. All items listed below shall be submitted altogether, in one set, to form a complete design review package. Approval of Work scope shop drawings by the COTR shall not relieve installation contractor of specified Work in this section, which may have been missing on the approved shop drawings.

B. Shop Drawings shall be submitted to COTR for approval prior to start of work. Prepare and provide standard, project customized details at a scale appropriate for understanding layering, terminations, anchorage, overlaps and embedment's. Do not proceed with WP-4 waterproofing installation without approved shop drawings. Submit drawings of Work Scope in plan

and sections, in addition all penetration(s), anchorage and special details of the following:

1. Sequence of waterproofing installation relative to construction sequence, including detailed installation procedure and system tie-ins to other systems when required.
2. Build-up of layered waterproofing at cracks and/or joints.

A. Product Data: Include material descriptions, 12” x 12” samples, SDS, technical data sheets, and installation instructions for crystalline waterproofing. Include the following:
1. Concentrated, reactive waterproofing powder,
2. Modified, reactive waterproofing powder,
3. Hydraulic cement,
4. Curing agents,
5. Reactive waterproofing mortars, and
6. Sample Panel 12”x12” represents WP-4 as entire system with each layer visible and labeled.

B. Product Certificates: For crystalline waterproofing, signed by product manufacturer.

C. Qualification Data: For Installer.

D. Manufacturer’s inspection reports of completed installation.

E. Minutes of preinstallation conference.

1.3 REFERENCES

A. Reference Standards: Latest edition as of Specification date.
1. American Society for Testing and Materials (ASTM) - ASTM International:
   a. ASTM C507 Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
   b. ASTM C1840 Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain and Storm Sewer Pipe.
   c. ASTM C42/C42M: Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   d. ASTM C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   e. ASTM D2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
   f. ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   g. ASTM A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
   h. ASTM C33, Standard Specification for Concrete Aggregate
   i. ASTM 050, Standard Specification for Portland Cement.

j. ASTM C940, Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory.
k. ASTM D1785, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
l. ASTM D2241, Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
m. ASTM F2304 Standard Practice for Rehabilitation of Sewers using Chemical Grouting (latest revision).
n. ASTM F2454 Standard Practice for Sealing Lateral Connections and lines from the mainline Sewer Systems by Lateral Packer Method, Using Chemical Grouting (latest revision).
o. ASTM 091, Standard Test Methods for Time of Setting of Hydraulic Cement by VI cat Needle.

B. State of Wisconsin Department of Transportation (Wis-Dot):
1. Standard Specification for Construction.
2. Standard Specifications for Construction of storm sewer and drainage structures.

C. Department of Labor, Occupational Safety and Health Administration (OSHA):
1. Occupational Safety and Health Standards – Excavations, Final Rule – 29 CFR, Part 1926

D. American National Standards Institute (ANSI):
1. Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD), Z535.1 Safety Color Code
2. ANSI/NSF 61, Drinking Water System Components – Health Effects.

E. American Public Works Association (APWA):
1. Uniform Color Code for Temporary Marking of Underground Utility Locations.

F. Other Applicable Standards:
1. API RP 13B-1, Recommended Practice for Field Testing Water-based Drilling Fluids.
2. National Association of Sewer Service Companies (NASSCO) prepared Pipeline Assessment and Certification Program (PACP), TV inspection form and sewer condition codes.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer. Workers shall have not less than 5 years documented successful experience with waterproofing work comparable to Work on this Project.

B. Preinstallation Conference: Conduct conference at Project site and document all discussions and agreements.

1.5 PROJECT CONDITIONS

A. Weather Limitations: Proceed with application only when existing and forecasted weather conditions permit crystalline waterproofing to be performed according to manufacturer's written instructions and warranty requirements.

B. Proceed with WP-4 waterproofing work only after all other grouting and waterproofing has been completed. Further proceed only after concrete substrate defects, including honeycombs, voids, and cracks, have been repaired to provide a sound substrate free of soil debris and water.

C. Ambient Conditions: Proceed with WP-4 waterproofing work only if temperature is maintained at 40 degrees F or above during work and cure period, and space is well ventilated and kept free of water.

1.6 MOCK-UP

A. Prior to application of specified WP-4 membrane/coating/slurry, and after of shop drawings, erect sample panel on site for mock-up using materials and joint details required for final work. Build mock-up at the site, where directed by COTR, of full thickness indicating the proposed color, texture, and workmanship to be expected in the completed work. Obtain COTR's acceptance of visual qualities of the mock-up before start of Work.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Available Products: Subject to compliance with requirements, products for crystalline waterproofing that may be incorporated into the Work include, but are not limited to, the following:
1. Aquafin, Inc: IC
2. Vandex International, Ltd: Vandex Super.
3. Xypex Chemical Corporation: Xypex.

2.2 MATERIALS

A. Crystalline Waterproofing: For first and second slurry coats, dry packing joints, and detail work. A prepackaged, gray-colored proprietary blend of portland cement, specially treated sand, and active chemicals that, when mixed with water and applied, penetrates by capillary action into concrete and reacts chemically with free lime in the presence of water to develop crystalline growth within concrete capillaries to produce an impervious, dense, waterproof concrete with properties meeting or exceeding the following criteria:
1. Permeability: 0 for water at 33 feet when tested according to CE CRD-C48.

2. Compressive Strength: 3000 psi when tested according to ASTM C 109/C109M.

B. Patching Compound: For mortar fill and dry-pack joints and cracks. Cementitious waterproofing and repair mortar for filling and patching drill holes, honeycombs, reveals, and other imperfections; with properties meeting or exceeding the following criteria:
1. Compressive Strength: 5600 psi at 28 days when tested according to ASTM C 109/C 109M.
2. Flexural Strength: 710 psi at 28 days when tested according to ASTM C 348.
Shrinkage: Minus 0.093 percent at 28 days and plus 0.073 percent at 90 days when tested according to ASTM C 596.

C. Plugging Compound: Cementitious compound with hydrophobic properties and resistant to water and moisture but vapor permeable for all standard applications; with properties meeting or exceeding the following criteria:
1. Permeability: 30 feet when tested according to CE CRD-C 48.
2. Compressive Strength: 6000 psi at 28 days when tested according to ASTM C 109/C 109 M.
3. Flexural Strength: 1000 psi at 28 days when tested according to ASTM C 348.
4. Bond Strength: 300 psi at 14 days when tested according to ASTM C 321.

D. Water: Potable.

E. First Slurry Coat: A coating on concentrated crystalline mortar.

F. Second Slurry Coat: A coating of modified crystalline mortar.

G. Curing Membrane: A spray applied manufacturer's approved curing compound.

H. Dry-pack mortar: A high viscosity mortar matrix of concentrated crystalline waterproofing agent.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Acceptance of Conditions: Examine substrates, with Applicator present, where waterproofing is to be applied.
1. Proceed with application only after unsatisfactory conditions have been corrected.
2. Notify COTR in writing of active leaks or structural defects that would affect system performance.

3.2 PREPARATION

A. Protect other work from damage from cleaning, preparation, and application of crystalline waterproofing. Provide temporary enclosure if spraying operation is used to confine and ensure adequate ambient temperatures and ventilation conditions for application.

B. Stop active water leaks according to waterproofing manufacturer's written instructions.

C. Repair damaged or unsatisfactory concrete according to manufacturer's written instructions.

D. Surface Preparation: Comply with waterproofing manufacturer's written instructions to remove efflorescence, chalk, dust, dirt/soil, mortar spatter, grease, oils, curing compounds, and form-release agents to ensure that waterproofing bonds to concrete surfaces.
   1. Clean concrete surfaces according to ASTM D 4258. Prepare -formed and trowel-finished concrete by mechanical abrading or abrasive-blast cleaning according to ASTM D 4259.
   2. Concrete Joints: Clean reveals according to waterproofing manufacturer's written instructions.

3.3 APPLICATION

A. General: Comply with waterproofing manufacturer's written instructions for application.
   1. Dampen surface with water and maintain damp condition until applying waterproofing.
   2. Apply waterproofing to interior concrete (inside) surfaces.
   3. Number of Coats: Two coats (1.5 pounds per square yard), for brush or spray application.
   4. Dampen surface between coats and cure per manufacturer's requirements.

B. Final Coat Finish: Brushed.

C. Moist-cure waterproofing for three days immediately after application has set followed by two days of air drying as recommended in writing by manufacture.

3.4 PROTECTION

A. Protect applied crystalline waterproofing from rapid drying, severe weather exposure, and water accumulation. Maintain completed Work in moist condition for not less than three days by procedures recommended in writing by waterproofing manufacturer. Protect waterproofing from temperatures below 36 deg F.

PART 4 - CONTRACTOR'S QUALIFICATIONS AND QA/QC REQUIREMENTS

4.1 GENERAL

A. Inspection:

1. Manufacturer's representative to inspect completed application and provide a written report that application complies manufacturer's instructions.

B. Product:
1. Supply and install only products specifically designed and manufactured for this type of construction.
2. Select manufacturers of accessory products who are regularly engaged in the production of similar materials for underground structures.

C. Supervision and Training of Personnel:
1. Execute all installation and testing under the direct supervision of an individual with minimum five (5)-years-experience in the installation of waterproofing systems for underground structures using membrane materials as specified.
2. Provide trained personnel for installation and testing operations.
3. The installer must have a minimum of five (5) years of experience in the installation of membranes/coatings in underground waterproofing installations.
4. The proficiency of each technician shall be demonstrated in the field for approval by the Contracting Officer's Technical Representative (COTR).
5. The waterproofing system shall be applied only by an approved contractor authorized by the Manufacturer prior to bid.
6. All work shall be completed by trained and authorized personnel.
7. Installation of waterproofing system shall be the responsibility of the Membrane Applicator to ensure undivided responsibility.
8. Upon request, the Applicator must submit a list of jobs performed by his employees and supervisors similar to the proposed system being bid.

D. Manufacturer's Performance:
1. Shall have documented experience of a minimum of 100,000 square feet.
2. The waterproofing products are to made by a nationally-recognized manufacturer specializing in waterproofing systems; have been used successfully on projects similar to this; and are appropriate for the substrate, groundwater, hydrostatic pressure, and soil and rock contamination conditions that may be expected in this Contract.

E. Installation Contractor:
1. Installation contractor of waterproofing and grouting materials shall be certified and/or approved by the manufacturer in writing prior to bid submission.

END OF SECTION 07 16 16

Project: 68" x 106" Horizontal Elliptical Reinforced Concrete Pipe Design, along Raymond Road, Madison, WI. Wisconsin Department of Transportation (WisDOT) Federal Project ID WISC 2017 402, State Project ID 5992-09-83, City of Madison, CTH M (CTH PD Intersection)

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Section 03 64 10 Polyacrylate Grout Crack Injection	WP-5
Section 03 64 23 Epoxy Resin Crack Injection	WP-6
Section 07 13 56 Thermoplastic Sheet Strip Seals	WP-7

Series: D, E, F - restoration technique & requirements for crack(s) in concrete pipe.
Series: A, B, G - restoration technique & requirements for tongue & groove pipe joints.
Series: C - soil stabilization & requirements at mid-section pipe haunch areas.

I hereby certify that the plan, specifications or report was prepared by me or under my direct supervision and that I am a duly registered Professional Engineer under the laws of the State of Wisconsin.

Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
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DES BA 1/9/2020
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: COVER

Project Narrative:

The design goal of this project is to enhance the service life via increasing durability and performance of Raymond Road elliptical concrete pipe. Chemical grouting at pipe joints and cementitious grouting at pipe haunch areas will serve to perform that function. In addition, treating existing cracks will improve corrosion resistance of reinforcing steel in concrete pipe sections.

Grout materials selected for this project have histories of long service life in municipal environments. Grout materials from specified manufacturers have proven records of performance in tunnel/piping systems.

Soil particles consisting of fine sand, silt and clay have been piping through various culvert pipe joints into the interior. Significant loss of soil particles to pipe interior may cause surface sink holes, void zones, and potentially lower the bearing resistance at culvert pipe invert and springlines, further sink holes appearing at the roadbed surface may occur.

Current seals at pipe joints consists of an asphalt mastic troweled into the tongue-and-recess flanges. In many cases that asphalt mastic has fallen out via groundwater fluctuations; differential, longitudinal or transverse pipe strain; and/or gravity, among other potential environmental considerations.

This elliptical concrete pipe restoration design serves to dramatically improves resistance of soil piping through joints and further increases soil bearing resistance between springlines and invert (haunch areas). The elliptical concrete pipe restoration work shall be performed in the following sequence:

1.) Step 1, Injection of hydrophilic polyurethane grout into elliptical concrete pipe tongue and recess joints to fill voids, adhere materials together, and establish an initial plug on exterior. This procedure will occur at every elliptical concrete pipe joint (approximately 495) as noted in Scope of Work drawings (pages 10 to 24). See “A” series drawings and Section 03 64 13 of the specifications as WP-1.

2.) Step 2, Injection of an acrylic grout (acrylamide) through same step 1 drill holes, however extended, to create a solidified soil mass at pipe joint exterior. Solidified soil mass increases soil strength and impedes soil particle flow with water movement at concrete pipe joints. This procedure will occur at every elliptical concrete pipe joint as noted in Scope of Work drawings (pages 10 to 24). The first 10 pipe sections (joints) at portals will use a glycol modified acrylic grout to provide freeze thaw resistance over time. See “B” series drawings and Section 03 64 20 of the specifications as WP-2.

3.) Step 3, involves soil solidification (SS) via permeation grouting (curtain grouting) in granular soils and fracture grouting in cohesive soils (soil stabilization) to improve soil bearing resistance between invert and springline areas (haunch locations). This procedure will occur at every elliptical concrete pipe mid-section joint as noted in the Scope of Work drawings (pages 10 to 24). See “C” series drawings and Section 03 61 10 of the specifications as SS-3.

4.) Steps 4, 5, and 6, could be interchanged without concern of sequence.

5.) Step 4 treatment procedures are for cracks equal to or less than 0.02 inches (0.02” = 20 mils). Crystalline treatment of cracks accelerates autogenous healing and reduces ability of fine silt and clay particle migration through said cracks. This procedure will occur at every elliptical concrete pipe section where noted on Scope of Work drawings (pages 10 to 24). See “D” series drawings and Section 07 16 16 of the specifications as WP-4.

6.) Step 5 treatment procedures are for cracks less than 0.040 inches (0.040” = 40 mils) and greater than 0.020 inches (0.020” = 20 mils). Polyacrylate grout crack injection via interception grouting of seals against water leakage and reduces ability of fine sand, silt and clay particle migration through said cracks. This procedure will occur at every elliptical concrete pipe mid-section where noted on the Scope of Work drawings (pages 10 to 24). See “E” series drawings and Section 03 64 10 of the specifications as WP-5.

7.) Step 6 treatment procedures are for cracks less than 0.120 inches (0.120” = 120 mils) and equal-to and greater than 0.040 inches (0.040” = 40 mils). Epoxy grout injection via surface mounting techniques seals against water leakage and reduces ability of medium sand, silt and clay particle migration through said cracks. This procedure will occur at every elliptical concrete pipe mid-section where noted on the Scope of Work drawings (pages 10 to 24). See “F” series drawings and Section 03 64 23 of the specifications as WP-6.

8.) Step 7 is treatment procedures for joints which equal or exceed one and one-half inches (1.5") in width at any location along the pipe joint. The possibility of interior joint seals (trowled-applied asphalt mastic) falling out from elliptical concrete pipe joints over time is higher in these wider situations. This procedure will occur at every elliptical concrete pipe joint in excess of 1.5 inches and where noted on the Scope of Work drawings (pages 10 to 24). See “G” series drawings and Section 07 13 56 of the specifications as WP-7.

9.) Step 8 is general filling (concrete mortar repair) of lift holes, spalls, through-anchor locations, divits, and chips at most elliptical concrete pipe sections with cementitious mortar equal in strength to the original concrete pipe (6,000 psi) (page 2).

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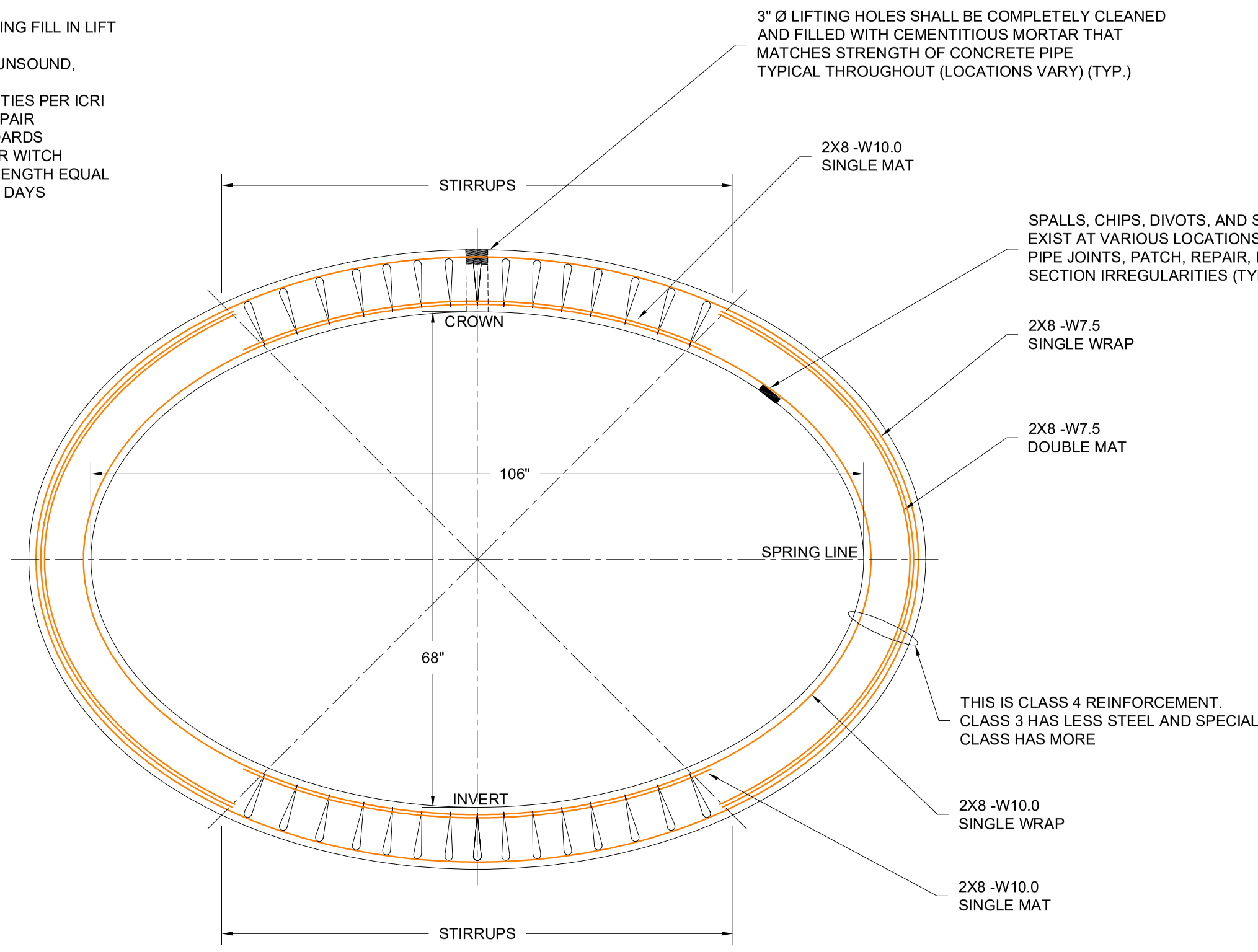
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 1

LIFT HOLES:

1. SOUND AREA TO ENSURE EXISTING FILL IN LIFT HOLE IS SOUND AND BONDED.
2. IF EXISTING PATCH MORTAR IS UNSOUND, REMOVE AND REPLACE
3. REPAIR CONCRETE IRREGULARITIES PER ICRI (INTERNATIONAL CONCRETE REPAIR INSTITUTE) ACCEPTABLE STANDARDS
4. USE CONCRETE REPAIR MORTAR WITCH PROVIDES A COMPRESSIVE STRENGTH EQUAL TO 6,000 PSI OR GREATER AT 28 DAYS



2 TYPICAL ELLIPTICAL PIPE REINFORCED CONCRETE PIPE

REPAIR OF LIFT HOLES AND SURFACE IRREGULARITIES

NOTE: THERE ARE 3 DIFFERENT REINFORCEMENT PATTERNS
SCALE: 1-1/2"=1'-0"

I hereby certify that the plan, specifications or report was prepared by me or under my direct supervision and that I am a duly registered Professional Engineer under the laws of the State of Wisconsin.

Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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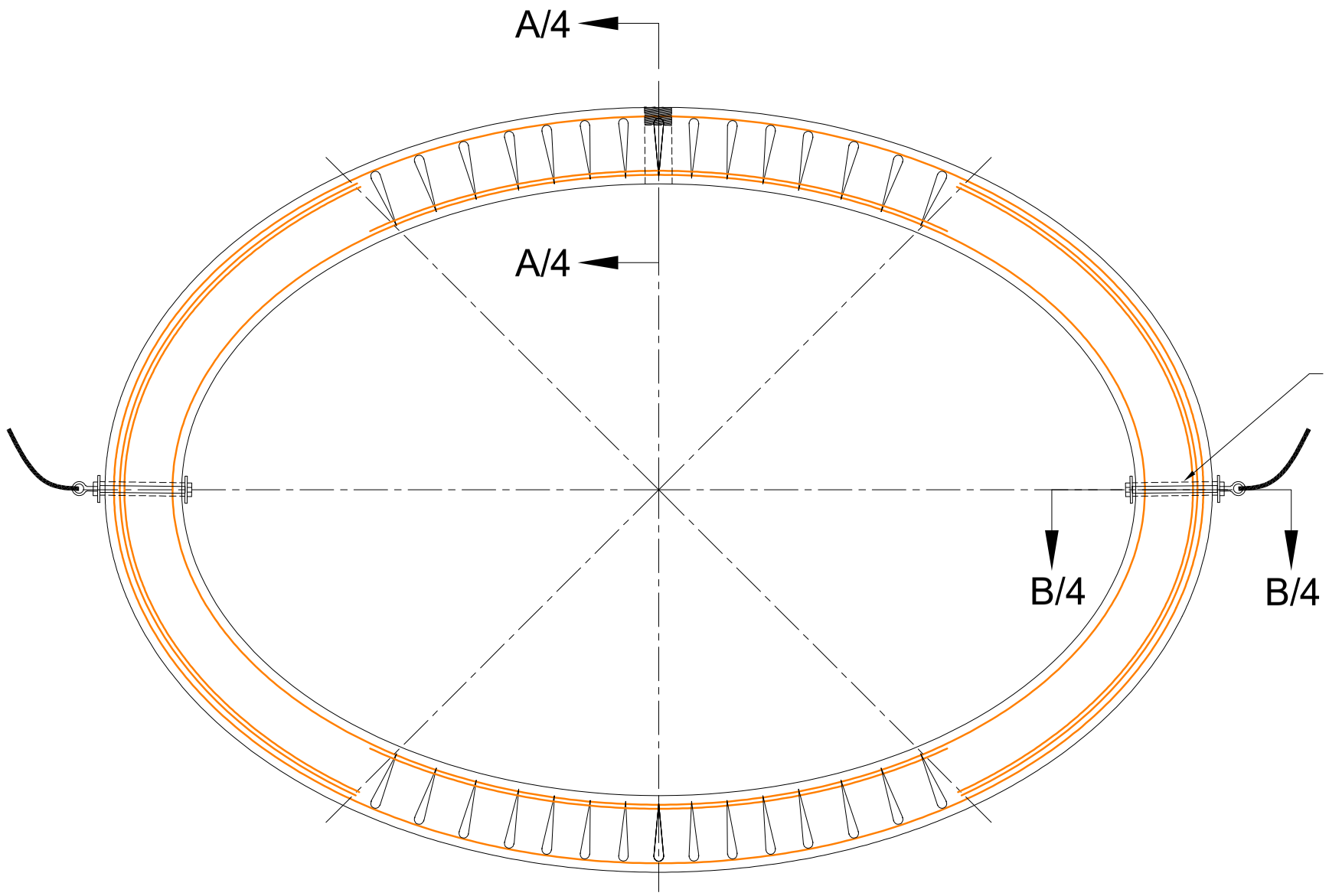
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 2

THRUST ANCHORS:

1. INJECT POLYURETHANE GROUT "A" SERIES PROTOCOL INTO ANNULUS SPACE OF EXPOSED ANCHORS NEAR PORTAL



3 STEEL THRUST ANCHOR, SEALS
SEALING ANCHOR PENETRATIONS AT PORTAL

SCALE: 1-1/2"=1'-0"

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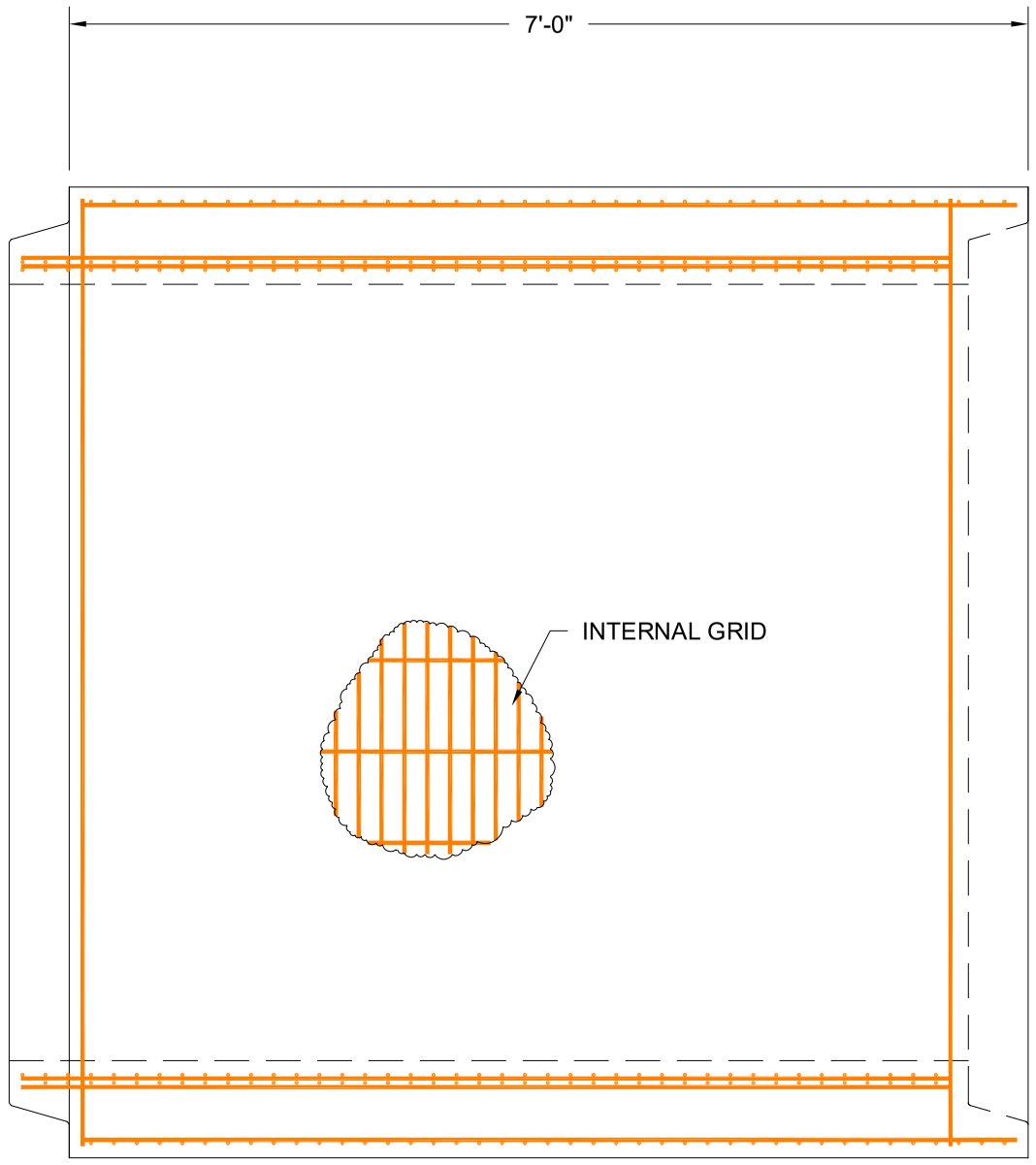
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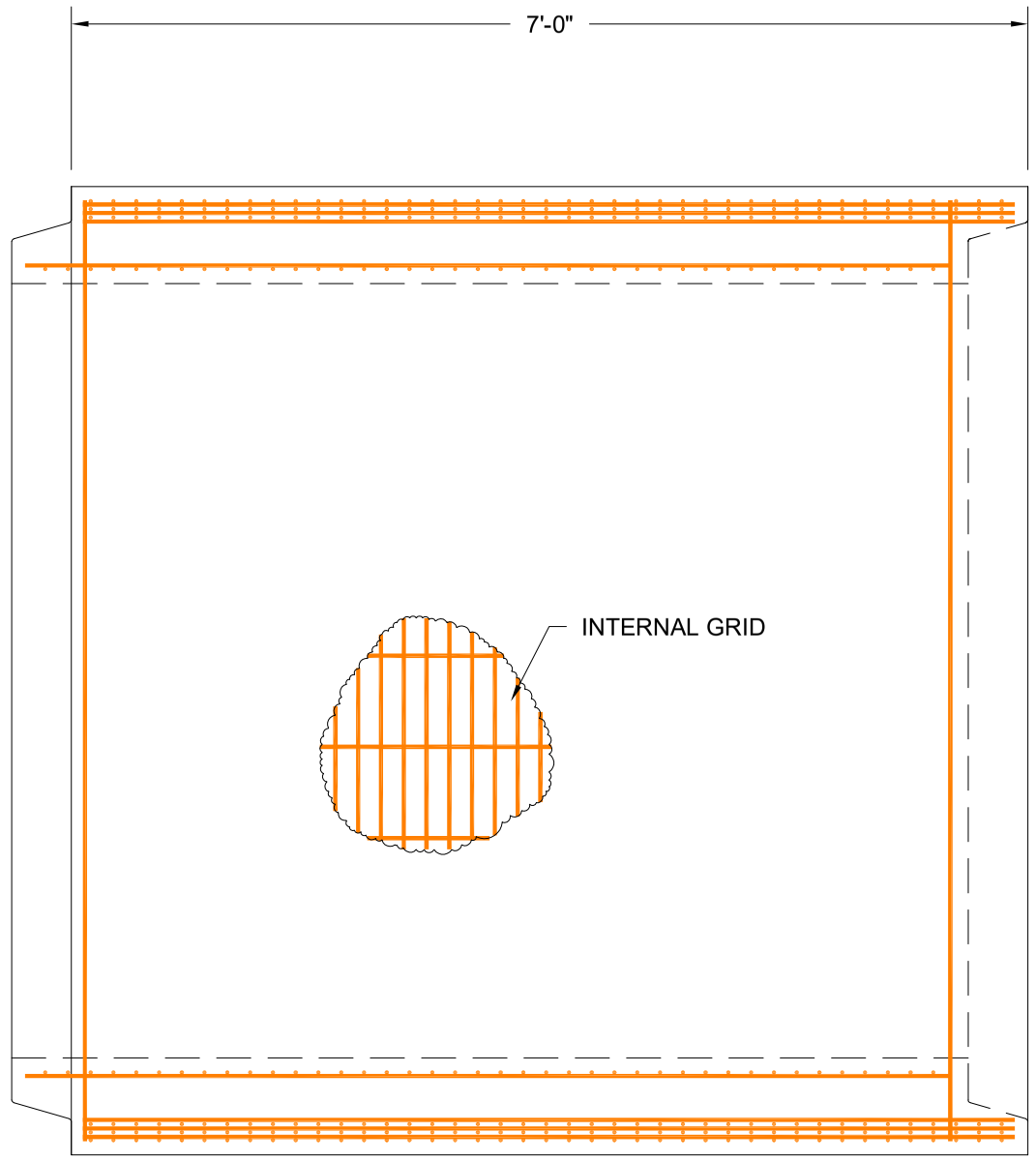
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 3



4A SECTION / ELEVATION OF CONCRETE PIPE @ CROWN & INVERT
Scale 1-1/2"=1'-0"



4B SECTION / ELEVATION OF CONCRETE @ SPRINGLINE
Scale 1-1/2"=1'-0"

4 TYPICAL ELLIPTICAL PIPE REINFORCED CONCRETE PIPE
NOTE: THERE ARE 3 DIFFERENT REINFORCEMENT PATTERNS

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1	1/9/2020		TB

DES	BA	1/9/2020
DRN	TB	1/9/2020
CHK	BA	1/9/2020

JOB NO.

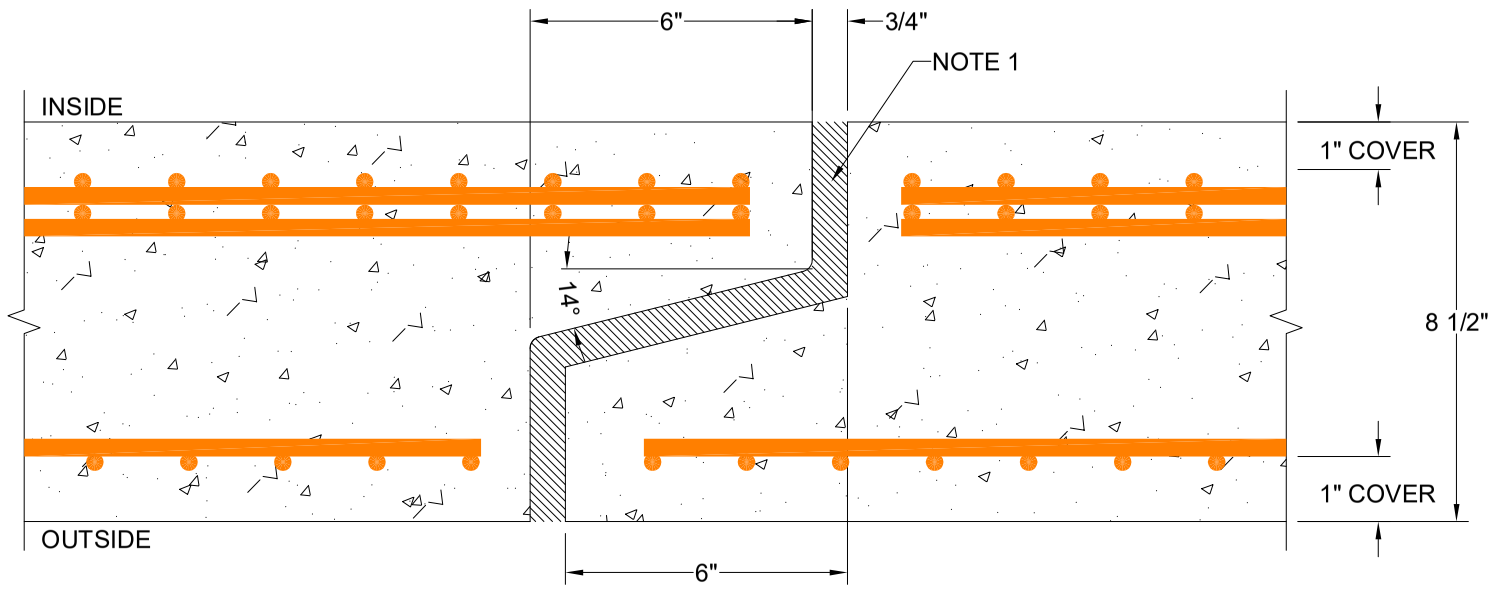
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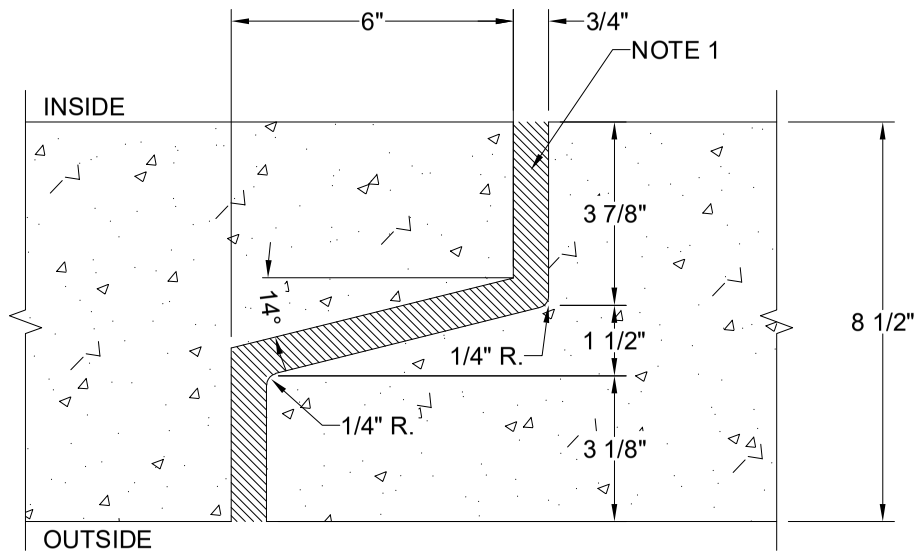
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 4

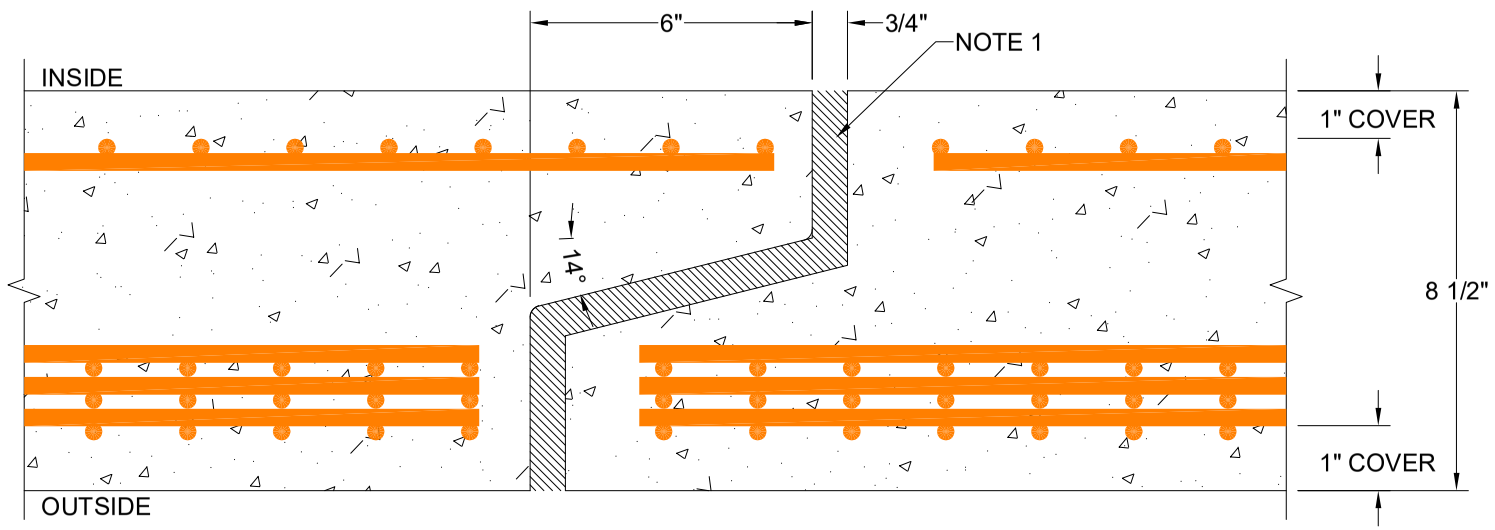
NOTE 1: PER PROJECT SPECIFICATIONS,
TROWELLED IN ASPHALT MASTIC IS TO BE
INSTALLED AT +/- 3/4" THICKNESS



5A CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"



5C CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"



5B CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"

5 SPECIFIED JOINT WIDTH
Scale 3"=1'-0"

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISIONS	BY
1	1/9/2020		TB

DES	DRN	CHK	JOB NO.
BA	TB	BA	
1/9/2020	1/9/2020	1/9/2020	

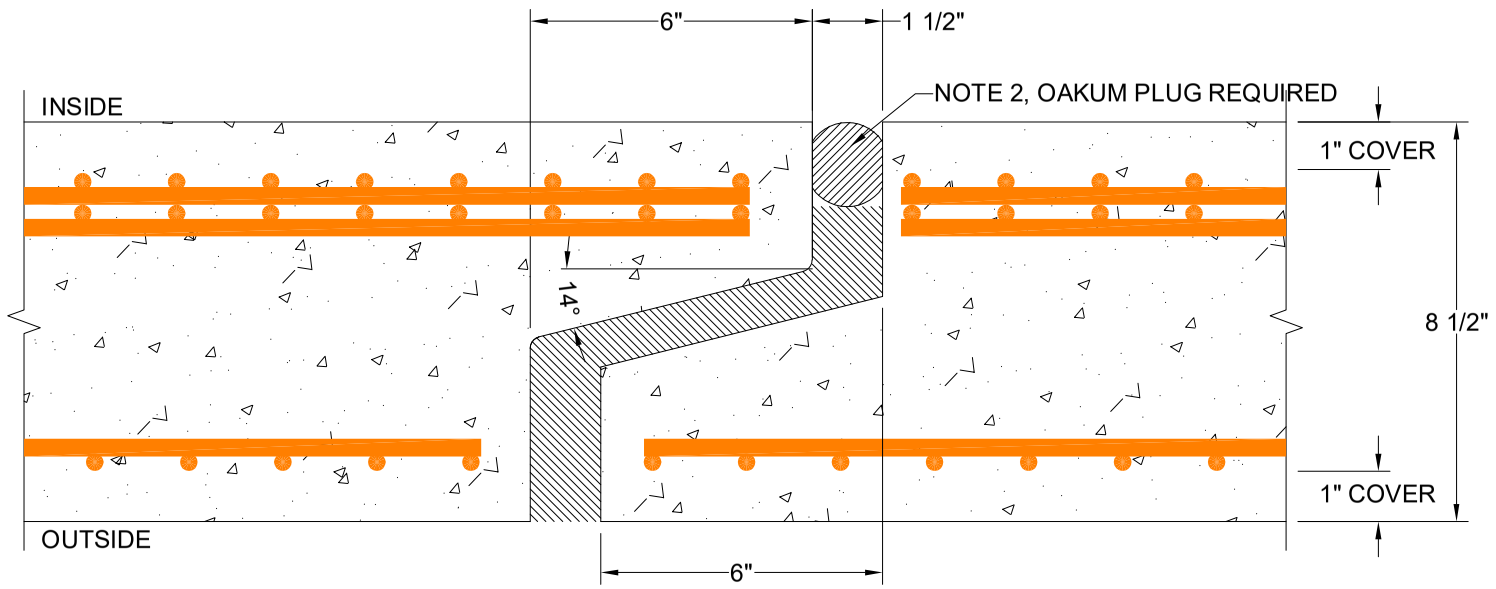
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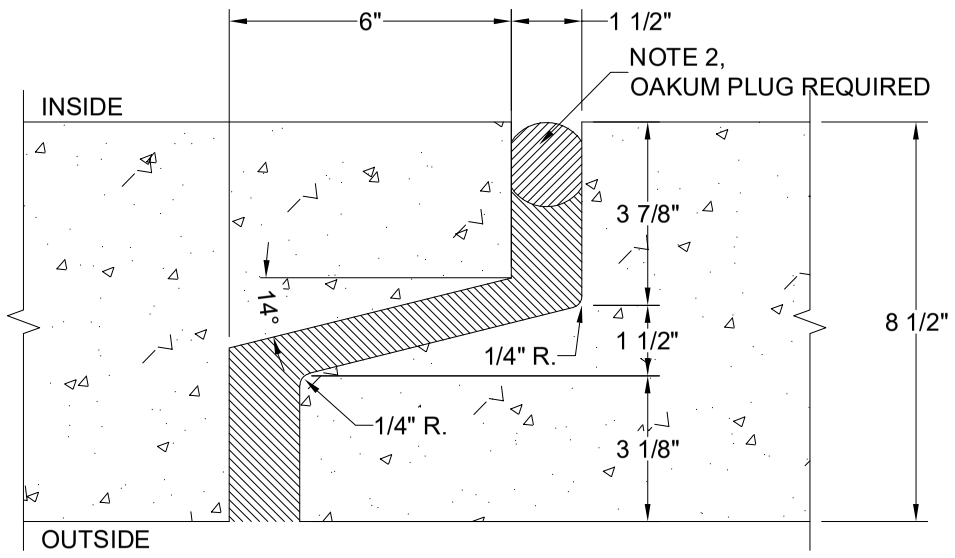
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 5

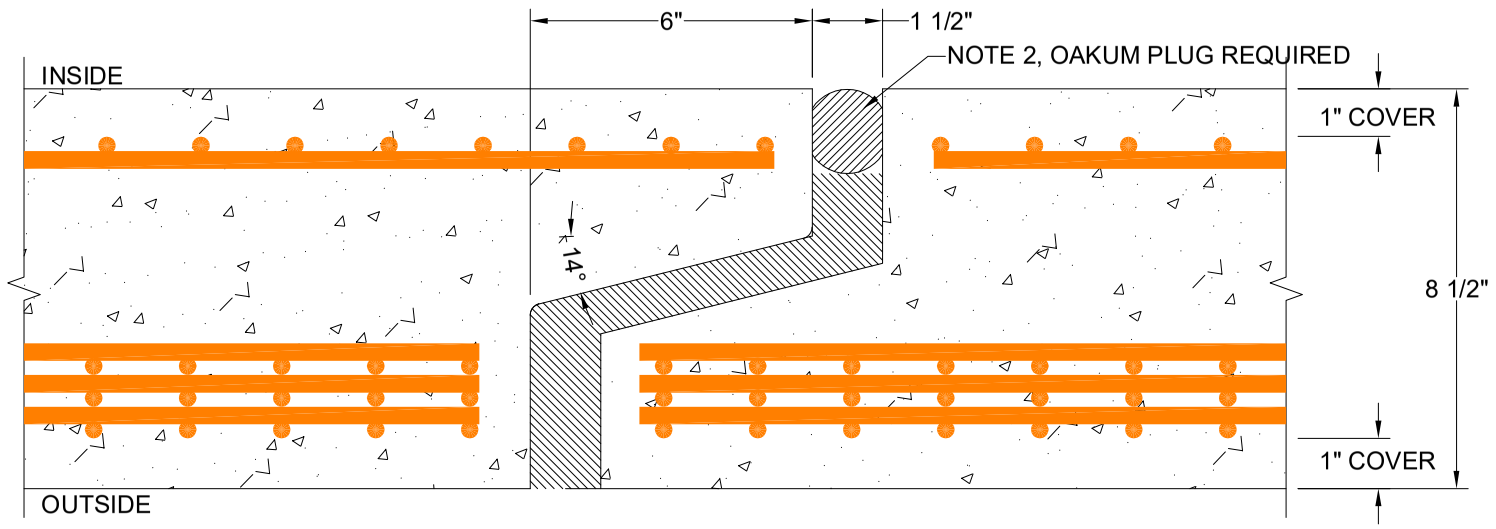
NOTE 2: ANY ELLIPTICAL CONCRETE PIPE JOINT THAT EXCEEDS 1.5 INCHES AT ANY LOCATION SHALL BE NOTED FOR INTERIOR TREATMENT IN ADDITION TO SERIES "A" AND "B" TREATMENTS



6A CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS



6C CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS



6B CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS

6 1-1/2" JOINT WIDTH
Scale 3"=1'-0"

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
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JOB NO.

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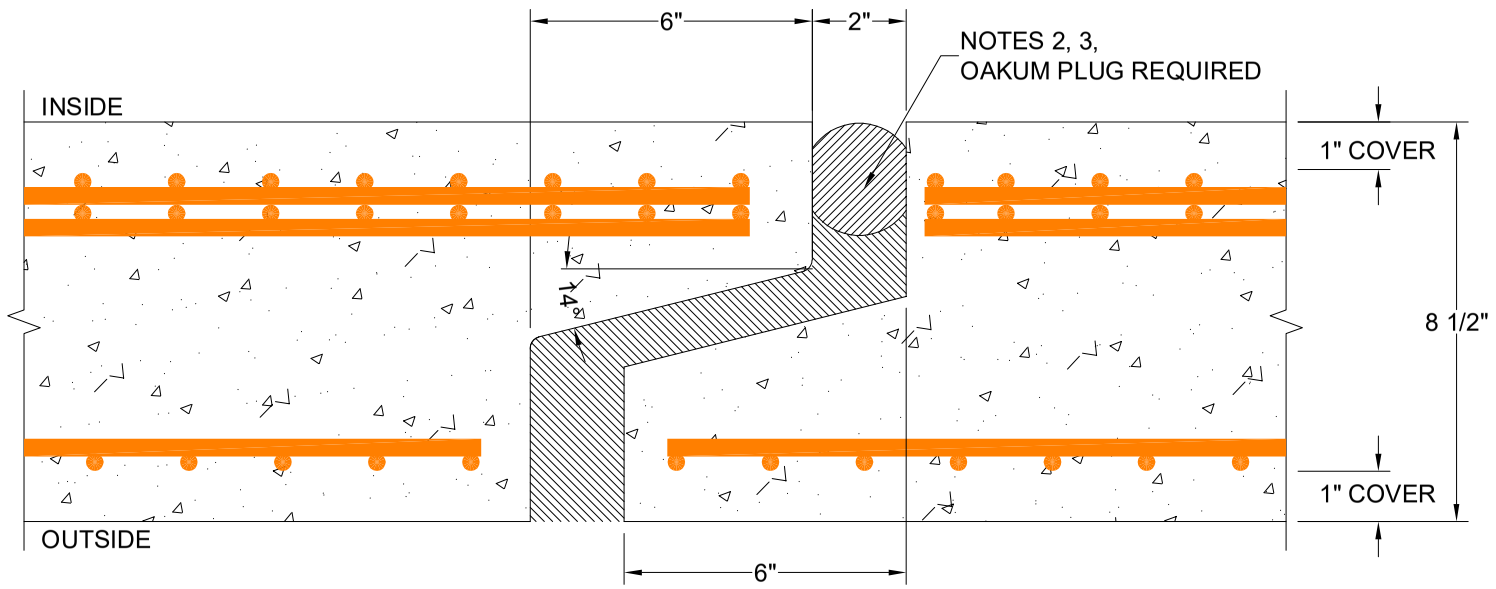
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RAYMOND ROAD CULVERT PIPE RESTORATION

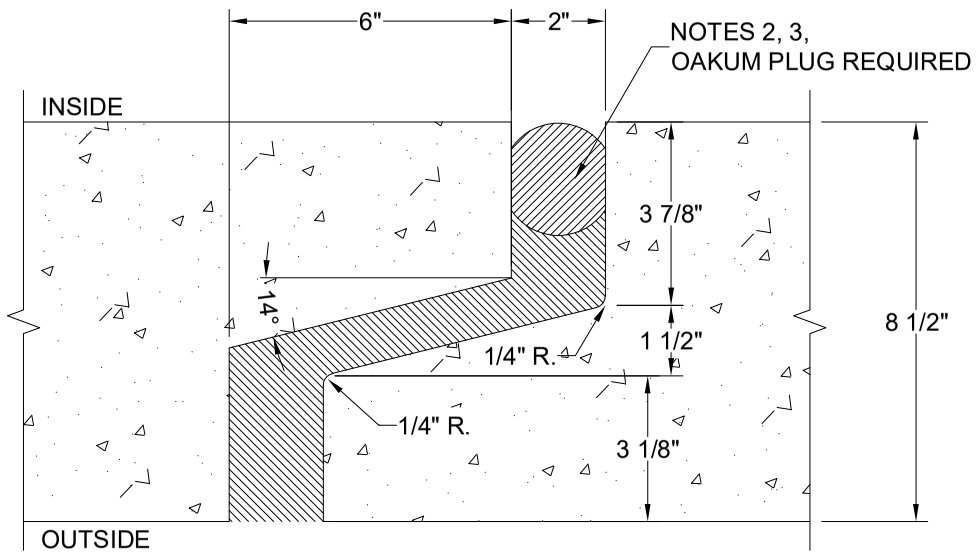
SHEET: 6

SEE SHEET 6 FOR NOTE 2

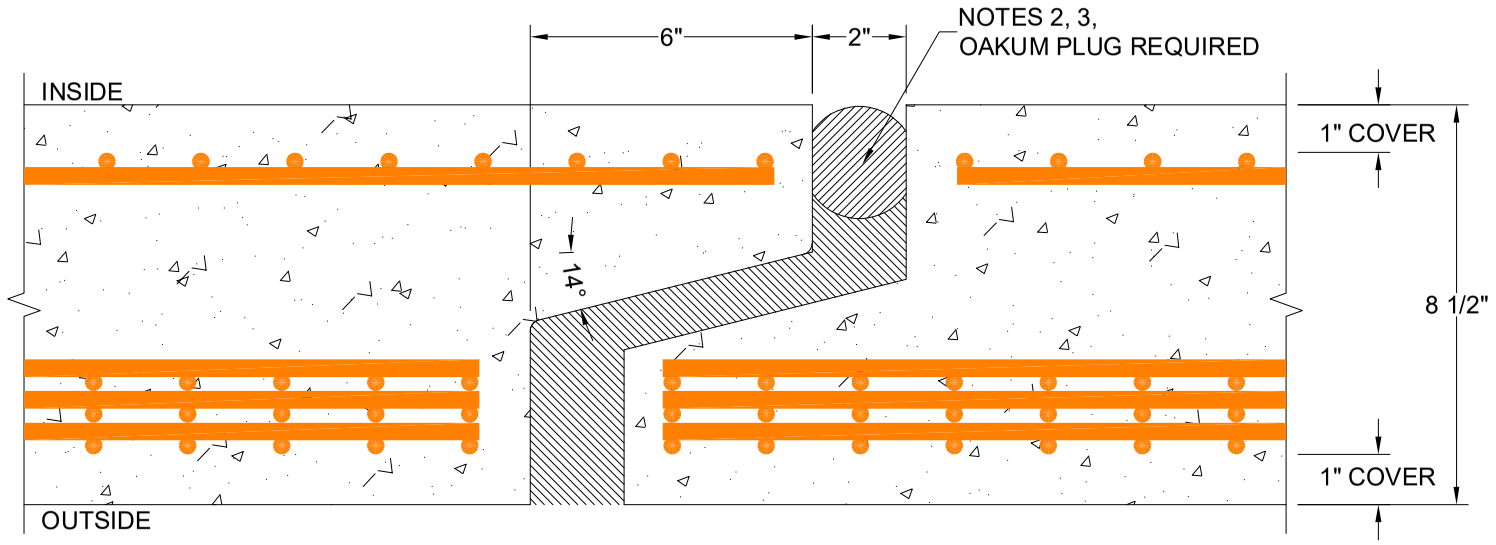
NOTE 3: JOINTS 2" AND WIDER MAY REQUIRE ADDITIONAL MATERIAL IN "A" AND "B" SERIES PROTOCOLS



7A CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS



7C CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS



7B CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS

7 2" JOINT WIDTH
Scale 3"=1'-0"

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By: Brent Anderson

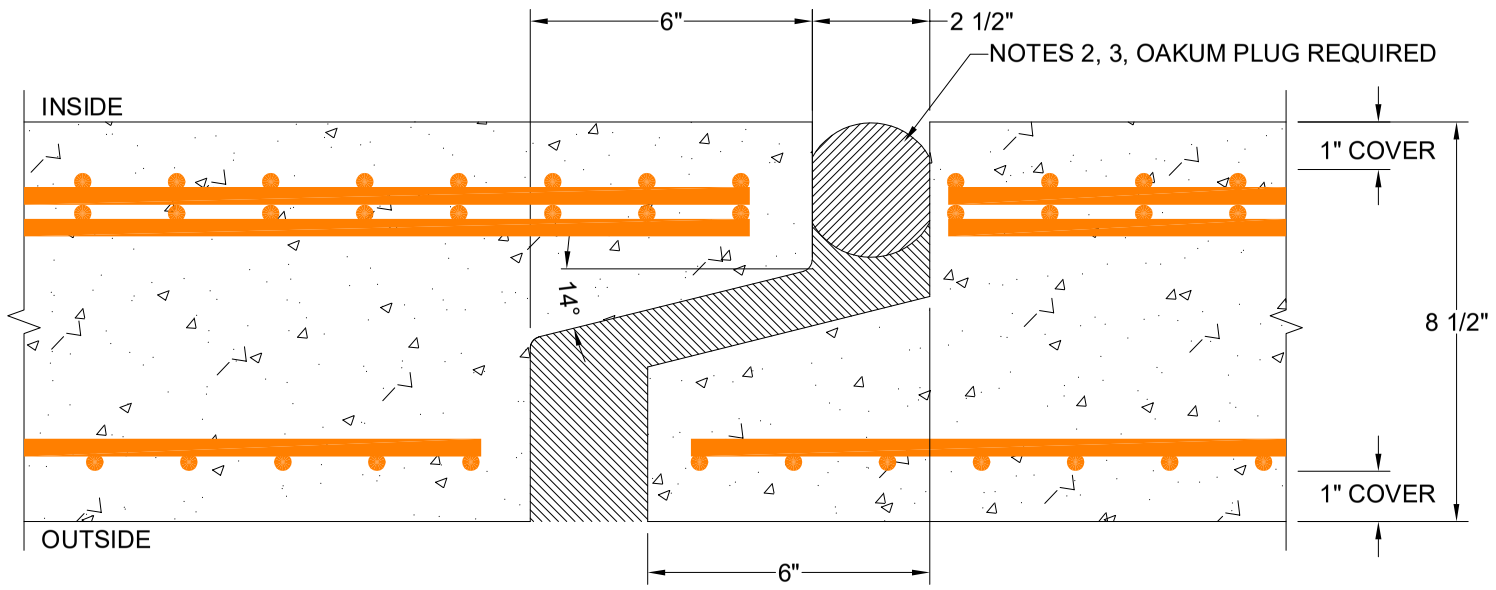
NO.	DATE	REVISION	BY
1	1/9/2020	REVISIONS	TB

DES	DRN	CHK	JOB NO.
BA	TB	BA	
1/9/2020	1/9/2020	1/9/2020	

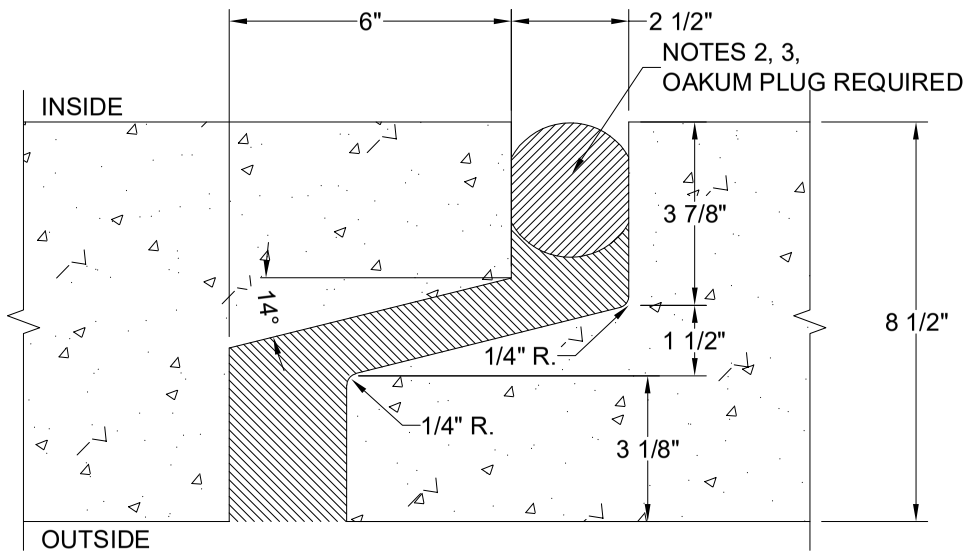
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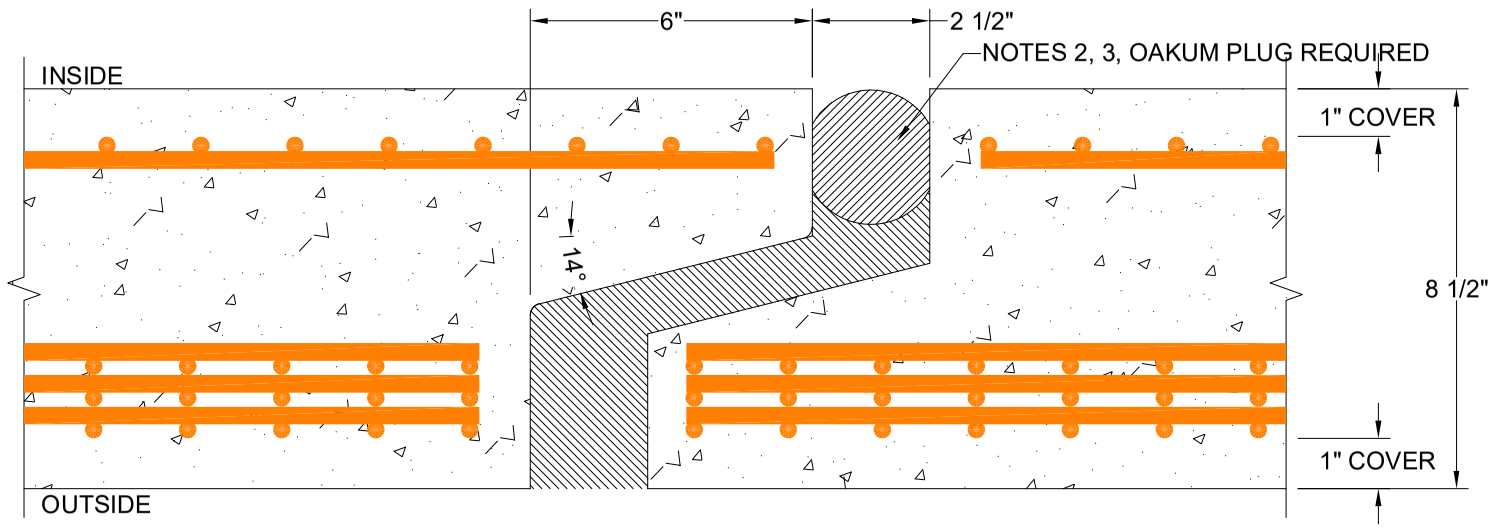
RAYMOND ROAD CULVERT PIPE RESTORATION



8A CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS



8C CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS



8B CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS

8 2-1/2" JOINT WIDTH
Scale 3"=1'-0"

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By: Brent Anderson

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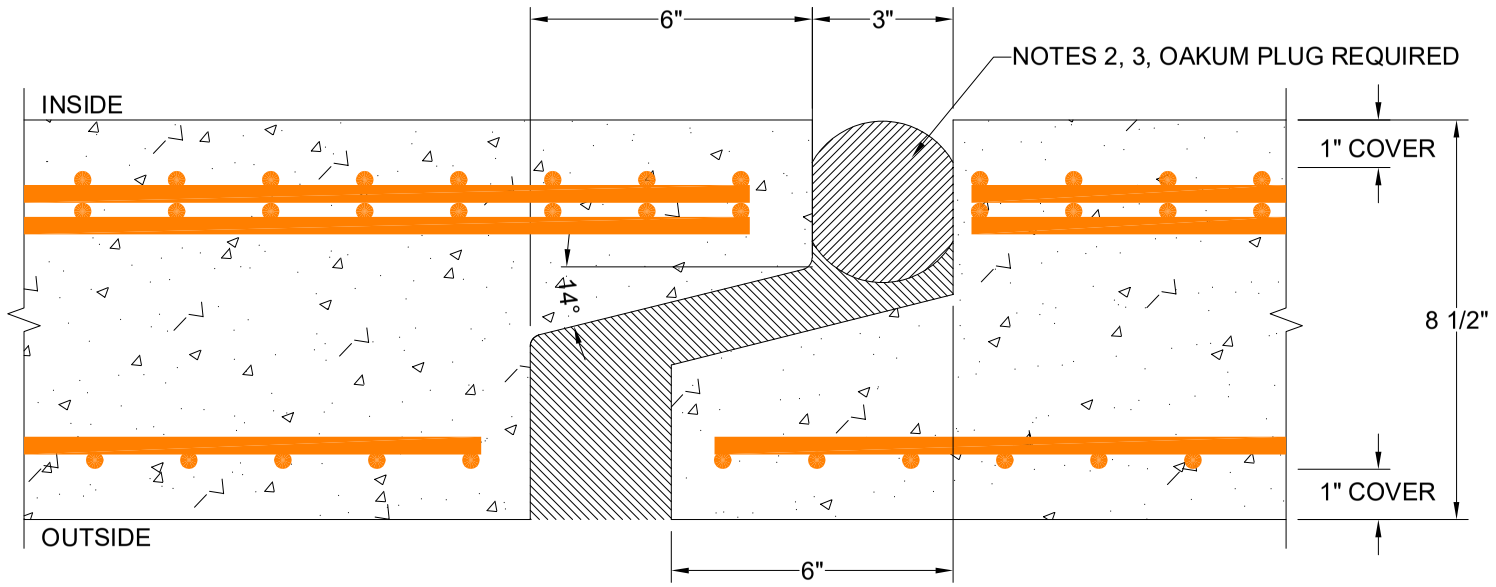
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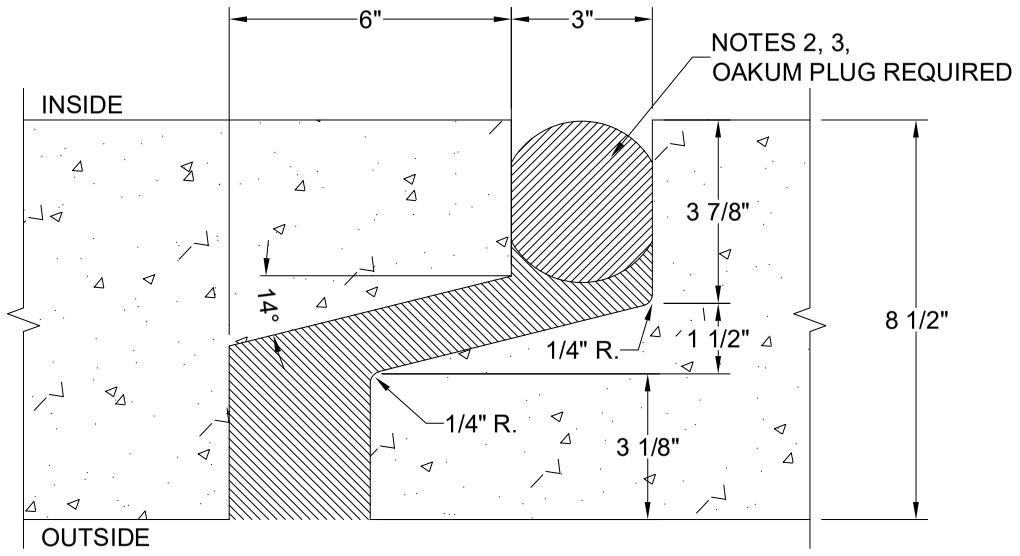
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RAYMOND ROAD CULVERT PIPE RESTORATION

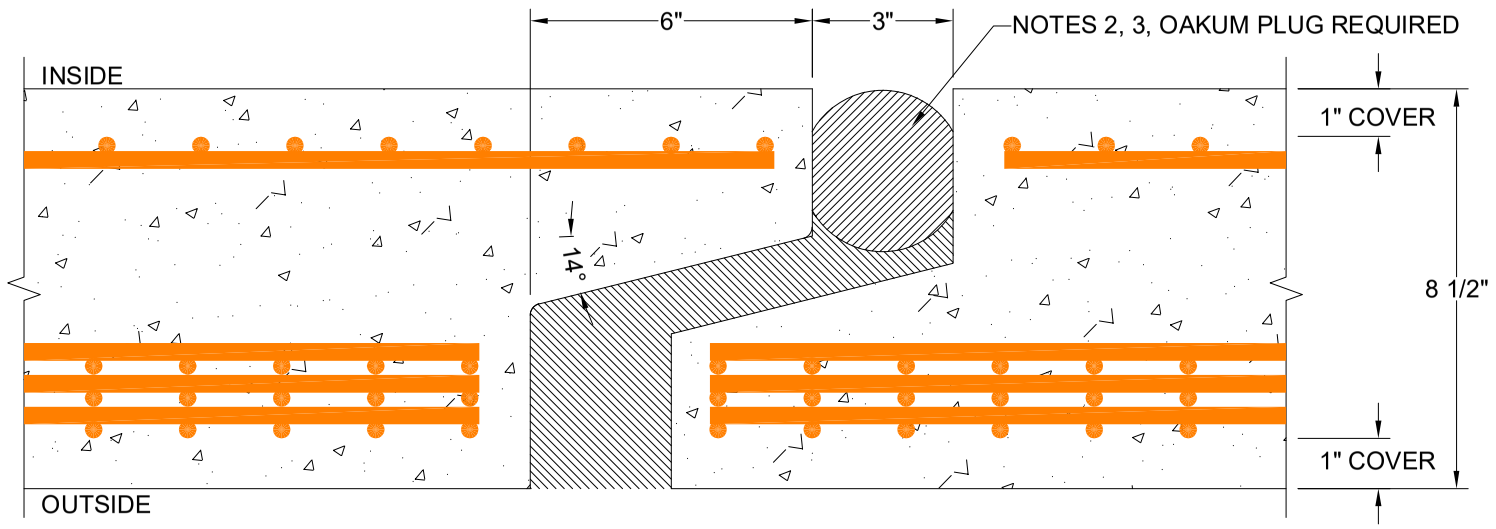
SHEET: 8



9A CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS



9C CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS



9B CONCRETE PIPE CULVERT TONGUE & GROOVE JOINT
Scale 3"=1'-0"
VARIOUS PIPE JOINT WIDTHS

9 3" JOINT WIDTH
Scale 3"=1'-0"

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 9

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
500+50		Survey Start								Direction of Survey is downstream goingup-stationing								
500+50		Access Point Manhole			12	12				Precast Box Manhole								
500+50		Miscellaneous General Observation		5.6	7	8.75				Precast elliptical pipe								
500+50		Deposits Settled Fine					1	5	7									
500+55		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
500+62		Crack Longitudinal			2	0.02		12						Y				
500+64		Surface Damage Other						11		Joint Chipped								Y
500+64		Surface Damage Other						1		Joint Chipped								Y
500+75		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
500+85		Surface Damage Other						10		Joint Chipped								Y
500+89		Surface Damage Reinforcement Visable	0.75					12		Lift Hole								Y
500+93		Crack Longitudinal			1	0.02		12						Y				
501+02		Crack Longitudinal			2	0.015		12						Y				
501+05		Crack Longitudinal			2	0.02		12						Y				
501+07		Crack Longitudinal			3	0.02		12						Y				
501+07		Miscellaneous General Observation		5.6	7.08	8.81				Barrel Check								
501+12		Crack Longitudinal			1.5	0.02		12						Y				
501+12		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
501+22		Crack Longitudinal			3	0.015		12						Y				
501+30		Crack Longitudinal			7	0.02		12						Y				
501+30		Crack Longitudinal			7	0.02		12						Y				
501+34		Crack Longitudinal			7	0.02		12						Y				
501+34		Crack Longitudinal			3	0.025		12							Y			
501+40		Crack Longitudinal			4	0.015		12						Y				
501+40		Crack Longitudinal			7	0.015		6						Y				
501+40		Crack Longitudinal			7	0.015		6						Y				
501+40		Crack Longitudinal			7	0.015		6						Y				
501+44		Crack Longitudinal			4	0.02		12						Y				
501+44		Crack Longitudinal			2	0.015		11						Y				
501+47		Crack Longitudinal			4	0.01		12						Y				
501+47		Crack Longitudinal			7	0.015		6						Y				
501+64		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
501+75		Crack Longitudinal			2	0.015		5						Y				
501+82		Crack Longitudinal			0.5	0.015		12						Y				
501+86		Joint Separated				1.75										Y		
501+86		Joint Offset				1				Vertical offset								
501+86		Miscellaneous General Observation		5.61	7.04	8.8				Barrel Check								
501+93		Crack Longitudinal			7	0.015		6						Y				
501+93		Crack Longitudinal			3	0.012		12						Y				
501+97		Surface Damage Surface Spalling			0.75	1.33				Lift Hole								Y
502+01		Joint Separated				2.5										Y		
502+03		Crack Longitudinal			3	0.15		12						Y				
502+09		Crack Longitudinal			7	0.015		12						Y				
502+12		Crack Longitudinal			7	0.02		6						Y				
502+13		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
502+23		Surface Damage Reinforcement Visable	0.08					12		Lift Hole								Y

10 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
1	1/9/2020	REVISIONS	TB

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1/9/2020	1/9/2020	1/9/2020	

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 10

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
			Feet			ft. / in.												
Start	End	Description	Dia	H	L	W	D	At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
502+32		Joint Separated				1											Y	
502+32		Joint Offset				0.875				Vertical								
502+38		Crack Longitudinal			3	0.01		12						Y				
502+38		Joint Separated				3											Y	
502+41		Crack Longitudinal			5	0.012		12						Y				
502+45		Crack Longitudinal			2.5	0.025		6							Y			
502+45		Crack Longitudinal			3	0.03		6							Y			
502+46		Surface Damage Surface Spalling						6		Joint								Y
502+47		Crack Longitudinal			5	0.03		12							Y			
502+55		Surface Damage Reinforcement Visable			0.58	0.83		12		Lift Hole								Y
502+59		Crack Longitudinal			7	0.015		12						Y				
502+66		Joint Separated				2											Y	
502+66		Joint Offset				0.25				Vertical								
502+66		Crack Longitudinal			4	0.15		5						Y				
502+66		Crack Longitudinal			7	0.03		12							Y			
502+70		Crack Longitudinal			2	0.02		1						Y				
502+76		Access Point Manhole			2.25	2		12										
502+80		Crack Longitudinal			7	0.02		6						Y				
502+80		Crack Longitudinal			3	0.012		6						Y				
502+80		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
502+80		Crack Longitudinal			4	0.02		12						Y				
502+82		Miscellaneous General Observation		5.6	7.04	8.83				Barrel Check								
502+82		Crack Longitudinal			1.5	0.03		9							Y			
502+82		Crack Circumferential			3	0.02		9	11	At a pipe bend				Y				
502+82		Crack Circumferential			7	0.035		1	5	At a pipe bend					Y			
502+83		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
502+85		Crack Longitudinal			5	0.012		6						Y				
502+85		Crack Longitudinal			5	0.012		7						Y				
502+85		Surface Damage Other						11		Chipped Joint								Y
502+85		Surface Damage Other						1		Chipped Joint								Y
502+85		Crack Longitudinal			1.5	0.015		12						Y				
502+85		Line Right																
502+90		Crack Longitudinal			4	0.015		12						Y				
502+94		Crack Longitudinal			1.5	0.02		12						Y				
503+04		Crack Longitudinal			4	0.025		12							Y			
503+07		Surface Damage Other						10		Chipped Joint								Y
503+19		Surface Damage Reinforcement Visable			1.17	0.67		12		Lift Hole								Y
503+21		Crack Longitudinal			0.75	0.01		12						Y				
503+22		Crack Longitudinal			7	0.02		12						Y				
503+25		Crack Longitudinal			3.5	0.012		5						Y				
503+30		Crack Longitudinal			3	0.02		12						Y				
503+30		Crack Longitudinal			3	0.02		12						Y				
503+34		Crack Longitudinal			3	0.01		12						Y				
503+36		Crack Longitudinal			7	0.012		12						Y				
503+37		Surface Damage Other						11		Chipped Joint								Y

11 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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BA	TB	BA	
1/9/2020	1/9/2020	1/9/2020	

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 11

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
			Feet			ft. / in.												
Start	End	Description	Dia	H	L	W	D	At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
503+37		Surface Damage Other						1		Chipped Joint								Y
503+44		Crack Longitudinal			3	0.025		12							Y			
503+55		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
503+68		Crack Longitudinal			4	0.012		12						Y				
503+71		Crack Longitudinal			7	0.01		12						Y				
503+81		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
503+83		Surface Damage Reinforcement Visable						11	12									Y
503+85		Crack Longitudinal			3	0.02		12						Y				
503+88		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
503+92		Crack Longitudinal			3	0.02		12						Y				
503+97		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
504+01		Crack Longitudinal			1.5	0.01		12						Y				
504+14		Crack Longitudinal			2	0.02		12						Y				
504+15		Crack Longitudinal			3	0.02		6						Y				
504+48		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
504+56		Crack Longitudinal			7	0.03		12							Y			
504+70		Crack Longitudinal			7	0.016		6						Y				
504+78		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
504+93		Crack Longitudinal			3	0.025		12							Y			
504+99		Surface Damage Reinforcement Visable	0.25					7										Y
505+11		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
505+25		Surface Damage	0.5					12		Lift Hole								Y
505+28		Surface Damage Other			1.5	5		7		Chipped Joint								Y
505+36		Crack Longitudinal			5	0.02		12						Y				
505+50		Crack Longitudinal			1.5	0.01		12						Y				
505+52		Crack Longitudinal			5	0.012		5						Y				
505+52		Crack Longitudinal			5	0.016		6						Y				
505+53		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
505+62		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
505+67		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
505+71		Surface Damage Reinforcement Visable			1			2										Y
505+82		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
505+89		Joint Separated				1.375											Y	
505+90		Surface Damage	0.5					12		Lift Hole								Y
505+98		Crack Longitudinal			3	0.02		12						Y				
506+07		Surface Damage Reinforcement Visable	0.5					12		Lift Hole								Y
506+11		Surface Damage AggregateVisable						11	12	At Joint								Y
506+35		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
506+48		Surface Damage ReinforcementVisable	0.5					10		Lift Hole								Y
506+48		Surface Damage ReinforcementVisable	0.5					2		Lift Hole								Y
506+50		Access Point Manhole			2	2		12										
506+52		Surface Damage ReinforcementVisable	0.5					10		Lift Hole								Y
506+52		Surface Damage ReinforcementVisable	0.5					2		Lift Hole								Y
506+55		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
506+65		Crack Longitudinal			7	0.03		7							Y			

12 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

I hereby certify that the plan, specifications or report was prepared by me or under my direct supervision and that I am a duly registered Professional Engineer under the laws of the State of Wisconsin.

Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
1	1/9/2020	REVISIONS	TB

DES	DRN	CHK	JOB NO.
BA	TB	BA	
1/9/2020	1/9/2020	1/9/2020	

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 12

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
506+72		Crack Longitudinal			7	0.03		5							Y			
506+80		Crack Longitudinal			7	0.03		5							Y			
506+85		Crack Longitudinal			7	0.02		5		Healed				Y				
506+85		Crack Longitudinal			7	0.02		7		Healed				Y				
506+88		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
506+92		Crack Longitudinal			7	0.18		5		Healed				Y				
506+92		Crack Longitudinal			5	0.028		12							Y			
506+98		Crack Longitudinal			7	0.028		5		Healed					Y			
506+98		Crack Longitudinal			7	0.02		6		Healed				Y				
507+06		Crack Longitudinal			3	0.025		12							Y			
507+10		Crack Longitudinal			2	0.015		12						Y				
507+13		Crack Longitudinal			7	0.02		5		Healed				Y				
507+13		Crack Longitudinal			2	0.02		12						Y				
507+20		Crack Longitudinal			2	0.02		12						Y				
507+23		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
507+43		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
507+47		Surface Damage Other						6		Chipped Joint								Y
507+61		Crack Longitudinal			7	0.01		5		Healed				Y				
507+91		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
508+00		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
508+20		Miscellaneous GeneralObservation		5.6	7.04	8.78				Barrel Check								
508+23		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
508+47		Surface Damage ReinforcementVisable	0.5					12		At Joint								Y
508+47		Surface Damage AggregateVisable						10	12	At Joint								Y
508+54		Joint Separated				1.75											Y	
508+54		Joint Offset				0.5				Vertical								
508+55		Surface Damage ReinforcementVisable			0.25	0.08		3		Rebar spacer visable, at joint								Y
508+68		Joint Separated				1.75											Y	
508+68		Joint Offset				0.5												
508+90		Surface Damage ReinforcementVisable			2	1		10	12									Y
508+90		Surface Damage Other						10		Chipped Joint								Y
508+90		Surface Damage Other						2		Chipped Joint								Y
509+05		Surface Damage Other						11		Chipped Joint								Y
509+05		Surface Damage Other						1		Chipped Joint								Y
509+29		Crack Longitudinal			7	0.03		5							Y			
509+45		Surface Damage ReinforcementVisable			1			11										Y
509+62		Crack Longitudinal			2	0.014		12						Y				
509+69		Surface Damage Other						7		Joint Chipped								Y
509+83		Crack Longitudinal			3	0.01		12						Y				
509+90		Joint Separated				2											Y	
509+93		Surface Damage AggregateVisable			1	7		12										Y
509+95		Crack Longitudinal			3.5	0.015		12						Y				
510+16		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
510+19		Crack Longitudinal			7	0.014		6		Healed				Y				
510+19		Crack Longitudinal			8	0.01		11						Y				

13 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

I hereby certify that the plan, specifications or report was prepared by me or under my direct supervision and that I am a duly registered Professional Engineer under the laws of the State of Wisconsin.

Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
1	1/9/2020	REVISIONS	TB

DES	DRN	CHK
BA	TB	BA
1/9/2020	1/9/2020	1/9/2020

JOB NO.

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 13

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
510+19		Crack Longitudinal			2	0.016		12						Y				
510+28		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
510+46		Surface Damage AggregateMissing	1					12		Lift Hole								Y
510+76		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
510+95		Surface Damage Surface Spalling						1		At joint								Y
511+09		Surface Damage ReinforcementVisable						10		At joint								Y
511+15		Crack Longitudinal			6	0.01		11						Y				
511+20		Crack Longitudinal			4	0.014		5		Healed				Y				
511+21		Crack Longitudinal			3.5	0.01		12						Y				
511+24		Crack Longitudinal			7	0.01		12						Y				
511+24		Crack Longitudinal			7	0.01		12						Y				
511+27		Surface Damage ReinforcementVisable	0.67					12		Lift Hole								Y
511+68		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
511+76		Surface Damage ReinforcementVisable	0.75					12		Lift Hole								Y
511+89		Crack Longitudinal			4	0.016		6						Y				
511+94		Joint Offset				0.875											Y	
511+97		Surface Damage AggregateMissing			0.83	1		12		Lift Hole								Y
512+18		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
512+25		Crack Circumferential			0.5	0.1		12		Possibly a tear						Y		
512+68		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
512+82		Surface Damage ReinforcementVisable	0.42					10										Y
512+83		Surface Damage ReinforcementVisable			1.75	1.5		12		Lift Hole								Y
512+90		Surface Damage ReinforcementVisable	0.67					12		Lift Hole								Y
512+97		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
513+04		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
513+11		Miscellaneous GeneralObservation						10		Debris in Lift Hole								Y
513+11		Miscellaneous GeneralObservation						2		Debris in Lift Hole								
513+13		Access Point Manhole			2	2		12										
513+15		Surface Damage ReinforcementVisable	0.5					10		Lift Hole								Y
513+15		Surface Damage ReinforcementVisable	0.5					2		Lift Hole								Y
513+22		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
513+40		Surface Damage Surface Spalling						11		At Joint								Y
513+69		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
514+12		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
514+18		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
514+29		Joint Separated				1.5											Y	
514+29		Joint Offset				0.75												
514+29		Miscellaneous GeneralObservation		5.55	7	8.83				Barrel Check								
514+43		Joint Separated				2.5											Y	
514+43		Joint Offset				0.5												
514+47		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
514+61		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
514+68		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
514+80		Joint Separated				1.9											Y	
514+80		Joint Offset				0.25												

14 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 14

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
514+90		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
514+93		Crack Longitudinal			7	0.016		5		Healed				Y				
514+93		Crack Longitudinal			7	0.014		6		Healed				Y				
514+93		Crack Longitudinal			7	0.016		6		Healed				Y				
514+97		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
515+00		Crack Longitudinal			7	0.016		6		Healed				Y				
515+14		Joint Separated				2											Y	
515+14		Joint Offset				0.25												
515+43		Joint Separated				2.5											Y	
515+43		Joint Offset				0.5												
515+68		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
515+72		Crack Longitudinal			7	0.02		7		Healed				Y				
515+79		Crack Longitudinal			7	0.02		7		Healed				Y				
515+86		Crack Longitudinal			7	0.02		7		Healed				Y				
515+93		Crack Longitudinal			7	0.02		7		Healed				Y				
516+00		Crack Longitudinal			7	0.02		5		Healed				Y				
516+00		Crack Longitudinal			7	0.02		7		Healed				Y				
516+07		Crack Longitudinal			7	0.02		5		Healed				Y				
516+14		Crack Longitudinal			7	0.02		5		Healed				Y				
516+14		Crack Longitudinal			7	0.02		7		Healed				Y				
516+21		Crack Longitudinal			7	0.02		5		Healed				Y				
516+21		Crack Longitudinal			7	0.02		7		Healed				Y				
516+28		Crack Longitudinal			7	0.015		7		Healed				Y				
516+32		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
516+35		Crack Longitudinal			7	0.02		5		Healed				Y				
516+35		Crack Longitudinal			7	0.02		7		Healed				Y				
516+43		Joint Separated				2											Y	
516+43		Joint Offset				0.25												
516+43		Crack Longitudinal			7	0.02		5		Healed				Y				
516+43		Crack Longitudinal			7	0.02		7		Healed				Y				
516+50		Crack Longitudinal			7	0.02		5		Healed				Y				
516+50		Crack Longitudinal			7	0.02		7		Healed				Y				
516+50		Surface Damage AggregateMissing			0.83	0.13		7		At Joint								Y
516+60		Surface Damage ReinforcementVisable	0.67					12		Lift Hole								Y
516+64		Crack Longitudinal			7	0.02		5		Healed				Y				
516+64		Crack Longitudinal			7	0.02		7		Healed				Y				
516+64		Surface Damage Surface Spalling						11		At Joint								Y
516+71		Crack Longitudinal			7	0.02		7		Healed				Y				
516+78		Crack Longitudinal			7	0.02		7		Healed				Y				
516+79		Surface Damage Surface Spalling						11		At Joint								Y
516+85		Joint Separated				1.75											Y	
516+85		Joint Offset				0.125												
516+85		Crack Longitudinal			7	0.014		5		Healed				Y				
516+85		Crack Longitudinal			7	0.014		7		Healed				Y				
516+86		Surface Damage Surface Spalling						11		At Joint								Y

(15) SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
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DES	DRN	CHK	JOB NO.
BA	TB	BA	
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 15

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
516+93		Crack Longitudinal			7	0.014		5		Healed				Y				
516+93		Crack Longitudinal			7	0.014		7		Healed				Y				
517+00		Crack Longitudinal			7	0.014		5		Healed				Y				
517+00		Crack Longitudinal			7	0.014		7		Healed				Y				
517+07		Crack Longitudinal			7	0.014		5		Healed				Y				
517+10		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
517+14		Crack Longitudinal			7	0.014		7		Healed				Y				
517+14		Surface Damage Surface Spalling						10		At Joint								Y
517+21		Crack Longitudinal			7	0.014		5		Healed				Y				
517+21		Crack Longitudinal			7	0.014		7		Healed				Y				
517+25		Surface Damage ReinforcementVisable			1.5	0.67		12		Lift Hole								Y
517+28		Crack Longitudinal			7	0.014		5		Healed				Y				
517+28		Crack Longitudinal			7	0.015		7		Healed				Y				
517+32		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
517+35		Crack Longitudinal			7	0.015		5		Healed				Y				
517+35		Crack Longitudinal			7	0.015		7		Healed				Y				
517+50		Joint Separated				2.125											Y	
517+50		Joint Offset				0.8												
517+58		Crack Longitudinal			7	0.015		5		Healed				Y				
517+61		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
517+65		Crack Longitudinal			7	0.15		7						Y				
517+71		Surface Damage ReinforcementVisable						6										Y
517+82		Surface Damage ReinforcementVisable	0.67					12		Lift Hole								Y
517+88		Surface Damage ReinforcementVisable	0.67					12		Lift Hole								Y
517+93		Crack Longitudinal			7	0.018		7		Healed				Y				
518+00		Joint Separated				0.25											Y	
518+00		Joint Offset				0.75												
518+10		Surface Damage ReinforcementVisable						6										Y
518+10		Surface Damage	0.67					12		Lift Hole								Y
518+14		Joint Separated				1.75											Y	
518+14		Joint Offset				0.125												
518+21		Joint Separated				2											Y	
518+21		Joint Offset				0.25												
518+42		Joint Separated				2											Y	
518+42		Joint Offset				0.25												
518+66		Crack Longitudinal			4	0.15		5						Y				
518+73		Joint Separated				1.75											Y	
518+73		Joint Offset				0.25												
518+79		Crack Longitudinal			7	0.015		7						Y				
519+15		Access Point Manhole			2	2		12										
519+43		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
519+50		Crack Longitudinal			7	0.016		5		Healed				Y				
519+50		Crack Longitudinal			7	0.016		7		Healed				Y				
519+55		Crack Longitudinal			3	0.02		12						Y				
519+57		Crack Longitudinal			7	0.016		5		Healed				Y				

16 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

I hereby certify that the plan, specifications or report was prepared by me or under my direct supervision and that I am a duly registered Professional Engineer under the laws of the State of Wisconsin.

Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
1	1/9/2020	REVISIONS	TB

DES	DRN	CHK	JOB NO.
BA	TB	BA	
1/9/2020	1/9/2020	1/9/2020	

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 16

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
519+57		Crack Longitudinal			7	0.016		7		Healed				Y				
519+72		Crack Longitudinal			1.5	0.02		12						Y				
519+74		Crack Longitudinal			3	0.01		12						Y				
519+95		Crack Longitudinal			3	0.016		7		Healed				Y				
519+95		Crack Longitudinal			3	0.016		5		Healed				Y				
519+97		Crack Longitudinal			7	0.02		5		Healed				Y				
519+97		Crack Longitudinal			7	0.02		7		Healed				Y				
520+00		Surface Damage ReinforcementVisable	0.83					12		Lift Hole								Y
520+03		Surface Damage Surface Spalling						2		At Joint								Y
520+04		Crack Longitudinal			7	0.02		7		Healed				Y				
520+22		Surface Damage Surface Spalling						11		At Joint								Y
520+30		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
520+33		Crack Longitudinal			2	0.02		6		Healed				Y				
520+37		Joint Separated				1.75											Y	
520+37		Joint Offset				0.25												
520+37		Crack Longitudinal			7	0.018		5		Healed				Y				
520+37		Crack Longitudinal			7	0.018		7		Healed				Y				
520+80		Joint Separated				1.75											Y	
520+80		Joint Offset				0												
520+83		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
521+05		Surface Damage AggregateMissing	1					12		Lift Hole								Y
521+30		Crack Longitudinal			7	0.01		12						Y				
521+30		Crack Longitudinal			4	0.01		5		Healed				Y				
521+30		Joint Separated				2.25											Y	
521+39		Crack Longitudinal			2	0.02		12						Y				
521+45		Surface Damage Surface Spalling						10		At Joint								Y
521+48		Surface Damage ReinforcementVisable	0.5					2		Lift Hole								Y
521+48		Surface Damage ReinforcementVisable	0.5					10		Lift Hole								Y
521+50		Access Point Manhole			2	2		12										
521+52		Surface Damage ReinforcementVisable	0.5					2		Lift Hole								Y
521+52		Surface Damage ReinforcementVisable	0.5					10		Lift Hole								Y
521+53		Surface Damage Surface Spalling						7		At Joint								Y
521+55		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
521+56		Crack Circumferential				0.02		3	6					Y				
521+57		Line Right																
521+58		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
521+68		Surface Damage Surface Spalling						1		At Joint								
521+68		Surface Damage Surface Spalling						10	11	At Joint								Y
521+82		Crack Longitudinal			7	0.016		5		Healed				Y				
521+82		Crack Longitudinal			7	0.016		7		Healed				Y				
521+82		Joint Separated				2											Y	
521+82		Joint Offset				0.125												
521+89		Crack Longitudinal			7	0.02		5		Healed				Y				
521+89		Crack Longitudinal			7	0.02		7		Healed				Y				
522+10		Joint Separated				2.5											Y	

17 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
1	1/9/2020	REVISIONS	TB

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1/9/2020	1/9/2020	1/9/2020	

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 17

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
522+25		Joint Separated				2.5											Y	
522+28		Surface Damage ReinforcementVisable	1					12		Lift Hole								Y
522+33		Crack Longitudinal			7	0.02		5		Healed				Y				
522+33		Crack Longitudinal			7	0.02		7		Healed				Y				
522+33		Crack Longitudinal			2	0.05		6								Y		
522+35		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
522+40		Crack Longitudinal			7	0.02		5		Healed				Y				
522+40		Crack Longitudinal			7	0.02		7		Healed				Y				
522+40		Joint Separated				2											Y	
522+40		Joint Offset				0.25												
522+64		Surface Damage ReinforcementVisable	0.83					12		Lift Hole								Y
522+82		Surface Damage Surface Spalling						10	11	At Joint								Y
522+98		Surface Damage ReinforcementVisable	0.67					12		Lift Hole								Y
523+10		Crack Longitudinal			7	0.02		5		Healed				Y				
523+10		Crack Longitudinal			7	0.02		7		Healed				Y				
523+17		Crack Longitudinal			7	0.02		5		Healed				Y				
523+17		Crack Longitudinal			7	0.02		7		Healed				Y				
523+21		Surface Damage ReinforcementVisable	0.83					12		Lift Hole								Y
523+31		Joint Separated				1.75											Y	
523+31		Joint Offset				0.25												
523+36		Surface Damage ReinforcementVisable	0.5					2		Lift Hole								Y
523+36		Surface Damage ReinforcementVisable	0.5					10		Lift Hole								Y
523+38		Access Point Manhole			2	2		12										
523+40		Surface Damage ReinforcementVisable	0.5					2		Lift Hole								Y
523+40		Surface Damage ReinforcementVisable	0.5					10		Lift Hole								Y
523+43		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
523+44		Line Right																
523+47		Crack Longitudinal			6	0.02		6		Healed				Y				
523+47		Crack Longitudinal			6	0.02		6		Healed				Y				
523+48		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
523+50		Joint Separated				1.75											Y	
523+50		Joint Offset				0.25												
523+50		Crack Longitudinal			3	0.016		5		Healed				Y				
523+50		Crack Longitudinal			3	0.016		7		Healed				Y				
523+51		Crack Longitudinal			2	0.005		12						Y				
523+54		Joint Separated				1.75											Y	
523+54		Joint Offset				0												
523+54		Crack Longitudinal			7	0.016		5		Healed				Y				
523+54		Crack Longitudinal			7	0.016		7		Healed				Y				
523+56		Crack Longitudinal			7	0.016		6						Y				
523+61		Crack Longitudinal			7	0.02		5		Healed				Y				
523+68		Crack Longitudinal			7	0.02		5		Healed				Y				
523+71		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
523+75		Crack Longitudinal			7	0.028		5		Healed					Y			
523+82		Crack Longitudinal			7	0.016		5		Healed				Y				

18 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
1	1/9/2020	REVISIONS	TB

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 18

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
			Feet			ft. / in.												
Start	End	Description	Dia	H	L	W	D	At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
523+82		Crack Longitudinal			7	0.016		6		Healed				Y				
523+82		Joint Separated				2											Y	
523+82		Joint Offset				1								Y				
523+82		Crack Longitudinal			7	0.05		6								Y		
523+86		Crack Longitudinal			4	0.05		6								Y		
523+94		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
524+01		Crack Longitudinal			7	0.016		6		Healed				Y				
524+10		Surface Damage Surface Spalling						10		At Joint								Y
524+25		Surface Damage Surface Spalling						10		At Joint								Y
524+28		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
524+32		Joint Separated				1.75											Y	
524+32		Joint Offset				0.25												
524+35		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
524+42		Infiltration Weeper						6		At joint	*	*						
524+43		Infiltration Weeper						6		At joint	*	*						
524+69		Surface Damage ReinforcementVisable	0.67					12		Lift Hole								Y
524+83		Surface Damage ReinforcementVisable	0.5					10		Lift Hole								Y
524+83		Surface Damage ReinforcementVisable	0.5					2		Lift Hole								Y
524+85		Access Point Manhole			2	2		12										
524+87		Surface Damage ReinforcementVisable	0.5					10		Lift Hole								Y
524+87		Surface Damage ReinforcementVisable	0.5					2		Lift Hole								Y
524+91		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
524+92		Line Right																
524+96		Surface Damage Surface Spalling						10		At Joint								Y
524+98		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
525+00		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
525+17		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
525+30		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
525+34		Infiltration Weeper						4			*	*						
525+34		Joint Separated				2.5											Y	
525+34		Infiltration Runner						8			*	*						
525+35		Joint Separated				2											Y	
525+35		Joint Offset				0.125												
525+48		Crack Longitudinal			2	0.005		12						Y				
525+52		Surface Damage ReinforcementVisable	1					12		Lift Hole								Y
525+70		Surface Damage Surface Spalling						10		At Joint								Y
525+70		Surface Damage Surface Spalling						2		At Joint								Y
525+85		Surface Damage Surface Spalling						1		At Joint								Y
525+85		Surface Damage Surface Spalling						10		At Joint								Y
525+89		Surface Damage ReinforcementVisable	0.67					12		Lift Hole								Y
525+92		Crack Longitudinal			7	0.025		6		Healed					Y			
525+99		Crack Longitudinal			7	0.016		5		Healed				Y				
525+99		Crack Longitudinal			7	0.02		7		Healed				Y				
526+09		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
526+11		Crack Longitudinal			7	0.012		5		Healed				Y				

19 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
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DES	DRN	CHK	JOB NO.
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 19

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
526+11		Crack Longitudinal			7	0.012		7		Healed				Y				
526+11		Crack Longitudinal			5	0.01		6						Y				
526+11		Crack Longitudinal			5	0.01		6						Y				
526+11		Crack Longitudinal			5	0.01		6						Y				
526+18		Crack Longitudinal			7	0.01		5		Healed				Y				
526+18		Crack Longitudinal			7	0.01		7		Healed				Y				
526+26		Crack Longitudinal			7	0.014		5		Healed				Y				
526+26		Crack Longitudinal			7	0.014		6		Healed				Y				
526+26		Crack Longitudinal			7	0.014		7		Healed				Y				
526+33		Crack Longitudinal			7	0.01		5		Healed				Y				
526+40		Crack Longitudinal			7	0.02		5		Healed				Y				
526+40		Crack Longitudinal			7	0.02		7		Healed				Y				
526+44		Surface Damage ReinforcementVisable	0.67					12		Lift Hole								Y
526+47		Joint Separated				1.75											Y	
526+47		Joint Offset				0.5												
526+47		Crack Longitudinal			7	0.028		5		Healed					Y			
526+47		Crack Longitudinal			7	0.028		7		Healed					Y			
526+54		Crack Longitudinal			7	0.016		6						Y				
526+54		Crack Longitudinal			7	0.01		5		Healed				Y				
526+54		Crack Longitudinal			7	0.01		7		Healed				Y				
526+59		Surface Damage ReinforcementVisable			1	1.5		12		Lift Hole								Y
526+61		Crack Longitudinal			7	0.01		5		Healed				Y				
526+61		Crack Longitudinal			7	0.01		6		Healed				Y				
526+61		Crack Longitudinal			7	0.01		7		Healed				Y				
526+69		Crack Longitudinal			7	0.016		5		Healed				Y				
526+69		Crack Longitudinal			7	0.016		6		Healed				Y				
526+69		Crack Longitudinal			7	0.016		6		Healed				Y				
526+76		Crack Longitudinal			7	0.02		6		Healed				Y				
526+76		Crack Longitudinal			7	0.01		5		Healed				Y				
526+76		Crack Longitudinal			7	0.01		7		Healed				Y				
526+87		Crack Longitudinal			7	0.02		7		Healed				Y				
526+87		Crack Longitudinal			7	0.02		6		Healed				Y				
526+92		Crack Longitudinal			7	0.01		5		Healed				Y				
526+96		Crack Longitudinal			7	0.01		5		Healed				Y				
526+96		Crack Longitudinal			5	0.02		6						Y				
526+97		Crack Longitudinal			5	0.02		7						Y				
526+98		Surface Damage AggregateMissing			2	0.25		6	7									Y
527+00		Crack Longitudinal			7	0.01		5		Healed				Y				
527+00		Crack Longitudinal			7	0.02		6						Y				
527+00		Crack Longitudinal			7	0.01		7		Healed				Y				
527+03		Surface Damage ReinforcementVisable	1.5					12		Lift Hole								Y
527+05		Crack Longitudinal			7	0.01		6						Y				
527+12		Crack Longitudinal			4	0.01		5						Y				
527+12		Crack Longitudinal			4	0.01		12						Y				
527+13		Crack Longitudinal			7	0.02		6						Y				
527+13		Crack Longitudinal			7	0.01		5		Healed				Y				

20 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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Date: 1/9/2020 Registration No: 23802-6

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 20

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
527+16		Crack Longitudinal			3	0.005		12						Y				
527+19		Crack Longitudinal			7	0.02		6						Y				
527+20		Crack Longitudinal			7	0.01		5		Healed				Y				
527+20		Crack Longitudinal			7	0.02		6		Healed				Y				
527+20		Crack Longitudinal			7	0.02		7		Healed				Y				
527+27		Crack Longitudinal			7	0.1		5		Healed						Y		
527+27		Crack Longitudinal			7	0.02		6		Healed				Y				
527+30		Crack Longitudinal			3	0.005		12						Y				
527+34		Crack Longitudinal			7	0.01		7		Healed				Y				
527+34		Crack Longitudinal			7	0.01		5		Healed				Y				
527+34		Crack Longitudinal			4	0.02		6						Y				
527+38		Crack Longitudinal			7	0.01		7		Healed				Y				
527+44		Crack Longitudinal			4	0.02		7						Y				
527+44		Crack Longitudinal			4	0.03		5							Y			
527+44		Crack Longitudinal			3	0.01		12						Y				
527+46		Crack Longitudinal			5	0.02		6						Y				
527+51		Crack Longitudinal			3	0.01		7						Y				
527+55		Joint Separated				2.25											Y	
527+55		Crack Longitudinal			1	0.02		7						Y				
527+65		Crack Longitudinal			5	0.01		5						Y				
527+65		Crack Longitudinal			5	0.01		7						Y				
527+68		Crack Longitudinal			7	0.01		5		Healed				Y				
527+68		Crack Longitudinal			7	0.01		7		Healed				Y				
527+75		Infiltration Runner						4		1 GPM, at joint	*	*						
527+84		Crack Longitudinal			5	0.02		6						Y				
527+84		Crack Longitudinal			7	0.035		7							Y			
527+87		Crack Longitudinal			5	0.06		6								Y		
527+87		Crack Longitudinal			7	0.02		7						Y				
527+90		Crack Multiple			4.5	0.02		6						Y				
527+97		Crack Longitudinal			7	0.015		5		Healed				Y				
527+97		Crack Longitudinal			7	0.015		6		Healed				Y				
527+97		Crack Longitudinal			7	0.02		6		Healed				Y				
527+98		Crack Longitudinal			7	0.01		5		Healed				Y				
527+98		Crack Longitudinal			7	0.016		6		Healed				Y				
528+04		Crack Longitudinal			7	0.01		5		Healed				Y				
528+04		Crack Longitudinal			7	0.018		6						Y				
528+04		Crack Longitudinal			7	0.01		5						Y				
528+07		Crack Longitudinal			3	0.015		7						Y				
528+10		Crack Longitudinal			7	0.015		6						Y				
528+24		Surface Damage ReinforcementVisable						6		Circumferential bars visable								Y
528+24		Crack Longitudinal			3	0.01		7		Healed				Y				
528+25		Crack Longitudinal			3	0.01		5		Healed				Y				
528+26		Crack Longitudinal			7	0.025		6							Y			
528+33		Crack Longitudinal			7	0.015		5						Y				
528+33		Crack Longitudinal			7	0.025		6							Y			

21 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

NO.	DATE	REVISION	BY
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 21

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
528+38		Crack Longitudinal			5	0.005		12						Y				
528+40		Crack Longitudinal			8	0.005		12						Y				
528+40		Crack Longitudinal			7	0.025		7							Y			
528+41		Crack Longitudinal			1	0.01		6						Y				
528+44		Crack Longitudinal			5	0.015		5		Healed				Y				
528+47		Joint Separated				1.25											Y	
528+47		Surface Damage AggregateMissing			1.58	0.21		6	7						Y			Y
528+54		Crack Longitudinal			4	0.01		5		Healed				Y				
528+54		Infiltration Weeper						7			*	*						
528+61		Crack Longitudinal			3	0.01		5		Healed				Y				
528+73		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
528+73		Crack Multiple			7	0.02		7						Y				
528+73		Crack Multiple			7	0.02		5						Y				
528+76		Infiltration Weeper						3		At Joint	*	*						
528+76		Crack Longitudinal			7	0.02		5						Y				
528+76		Crack Longitudinal			4	0.01		7		Healed				Y				
528+76		Crack Longitudinal			7	0.015		6						Y				
528+76		Crack Longitudinal			1	0.005		11						Y				
528+76		Crack Longitudinal			1	0.005		12						Y				
528+78		Crack Longitudinal			4	0.01		5						Y				
528+80		Crack Longitudinal			4	0.015		7						Y				
528+81		Crack Longitudinal			7	0.015		6						Y				
528+82		Crack Longitudinal			4	0.02		7						Y				
528+83		Joint Separated				1.75											Y	
528+83		Joint Offset				0.125												
528+83		Crack Longitudinal			7	0.02		5						Y				
528+83		Crack Longitudinal			7	0.02		7						Y				
528+83		Crack Circumferential			1	0.035		6	7	At Joint					Y			
528+84		Infiltration Weeper						9			*	*						
528+86		Crack Longitudinal			4	0.02		6						Y				
528+90		Crack Longitudinal			4	0.01		5		Healed				Y				
528+90		Crack Longitudinal			4	0.02		7						Y				
528+90		Joint Separated				3											Y	
528+90		Joint Offset				0.5												
528+90		Crack Multiple			4.5	0.02		6	7					Y				
528+96		Crack Longitudinal			2	0.005		12						Y				
529+06		Crack Longitudinal			3	0.02		6						Y				
529+08		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
529+25		Surface Damage Surface Spalling						7		At Joint								Y
529+26		Crack Longitudinal			1	0.01		12						Y				
529+26		Crack Longitudinal			7	0.02		6						Y				
529+42		Crack Longitudinal			7	0.025		6							Y			
529+45		Crack Longitudinal			7	0.005		7						Y				
529+51		Crack Longitudinal			7	0.01		6						Y				
529+75		Crack Circumferential			2	0.03		4	5						Y			

22 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 22

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
529+90		Joint Separated				2.25											Y	
529+95		Miscellaneous GeneralObservation		5.55	7	8.72				Barrel Check								
529+97		Surface Damage Surface Spalling						3		At Joint								Y
529+98		Surface Damage ReinforcementVisable	0.5					10		Lift Hole								Y
529+98		Surface Damage ReinforcementVisable	0.5					2		Lift Hole								Y
530+00		Obstruction Construction Debris			2.5	2		6		Concrete overpour								
530+00		Access Point Manhole			2	2		12										
530+02		Surface Damage ReinforcementVisable	0.5					10		Lift Hole								Y
530+02		Surface Damage ReinforcementVisable	0.5					2		Lift Hole								Y
530+03		Crack Longitudinal			7	0.25		6							Y			
530+07		Crack Circumferential			4	0.005		3	5					Y				
530+07		Line Right																
530+13		Crack Longitudinal			2	0.005		12						Y				
530+14		Crack Longitudinal			3	0.01		12						Y				
530+14		Surface Damage Surface Spalling						1		At Joint								Y
530+15		Crack Longitudinal			2	0.01		12						Y				
530+15		Surface Damage Surface Spalling						5		At Joint								Y
530+22		Crack Longitudinal			7	0.01		5		Healed				Y				
530+23		Surface Damage ReinforcementVisable	0.75					12		Lift Hole								Y
530+23		Crack Longitudinal			2	0.01		12						Y				
530+25		Crack Longitudinal			4	0.01		1						Y				
530+27		Crack Longitudinal			7	0.01		12						Y				
530+28		Joint Separated				2.25											Y	
530+29		Crack Longitudinal			7	0.01		7		Healed				Y				
530+31		Surface Damage ReinforcementVisable	0.5					12		Lift Hole								Y
530+31		Surface Damage AggregateMissing	1					12		Lift Hole								Y
530+31		Crack Longitudinal			3	0.01		12						Y				
530+35		Crack Longitudinal			2	0.005		12						Y				
530+40		Crack Longitudinal			5	0.01		1						Y				
530+42		Crack Longitudinal			7	0.01		12						Y				
530+42		Crack Longitudinal			7	0.01		11						Y				
530+47		Crack Spiral			6	0.02		6	7					Y				
530+50		Crack Longitudinal			7	0.03		6							Y			
530+57		Crack Longitudinal			7	0.025		6							Y			
530+57		Joint Separated				2.75											Y	
530+57		Surface Damage AggregateMissing			2	0.5		6	7									Y
530+58		Crack Longitudinal			7	0.015		7						Y				
530+64		Crack Longitudinal			7	0.02		6						Y				
530+64		Crack Longitudinal			7	0.03		7							Y			
530+64		Crack Longitudinal			7	0.01		8		Healed				Y				
530+66		Crack Longitudinal			7	0.005		6						Y				
530+67		Crack Longitudinal			7	0.015		6						Y				
530+72		Crack Longitudinal			7	0.005		6						Y				
530+72		Crack Longitudinal			7	0.005		7						Y				
530+78		Crack Longitudinal			7	0.025		6							Y			

23 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 23

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
530+78		Crack Longitudinal			7	0.025		7							Y			
530+85		Crack Longitudinal			7	0.05		5								Y		
530+85		Crack Longitudinal			7	0.05		6								Y		
530+85		Crack Longitudinal			7	0.04		7							Y			
530+85		Surface Damage Surface Spalling						11		At Joint								Y
530+89		Crack Longitudinal			5	0.005		11						Y				
530+90		Access Point Manhole			2	2		12										
530+92		Crack Longitudinal			7	0.005		12						Y				
530+92		Crack Longitudinal			4	0.01		12						Y				
530+92		Crack Longitudinal			7	0.03		6							Y			
530+96		Line Right																
530+98		Crack Circumferential				0.02		3	5					Y				
530+99		Surface Damage Surface Spalling			1	1		6		At Joint								Y
531+00		Joint Separated				2											Y	
531+00		Joint Offset				0.25												
531+00		Crack Longitudinal			7	0.01		5		Healed				Y				
531+00		Crack Longitudinal			7	0.01		7		Healed				Y				
531+01		Surface Damage Surface Spalling						5		At Joint								Y
531+15		Crack Longitudinal			7	0.01		5		Healed				Y				
531+15		Crack Longitudinal			7	0.01		7		Healed				Y				
531+15		Crack Longitudinal			4	0.025		6							Y			
531+18		Joint Separated				2											Y	
531+18		Joint Offset				0.25												
531+23		Crack Longitudinal			5	0.05		6								Y		
531+25		Crack Longitudinal			7	0.03		6							Y			
531+25		Crack Longitudinal			7	0.01		5		Healed				Y				
531+25		Crack Longitudinal			7	0.01		7		Healed				Y				
531+30		Crack Longitudinal			7	0.018		5		Healed				Y				
531+30		Crack Longitudinal			7	0.01		7		Healed				Y				
531+32		Miscellaneous GeneralObservation		5.55	7	8.72				Barrel Check								
531+34		Crack Longitudinal			3	0.11		6						Y				
531+37		Crack Longitudinal			7	0.02		6						Y				
531+38		Crack Longitudinal			7	0.02		6						Y				
531+38		Crack Longitudinal			7	0.03		7							Y			
531+38		Crack Longitudinal			4	0.01		5						Y				
531+41		Crack Longitudinal			4	0.03		6							Y			
531+51		Crack Longitudinal			3	0.025		6							Y			
531+55		Crack Longitudinal			7	0.01		5		Healed				Y				
531+55		Crack Longitudinal			7	0.01		7		Healed				Y				
531+69		Crack Longitudinal			7	0.03		5							Y			
531+75		Crack Longitudinal			7	0.05		6								Y		
531+85		Crack Longitudinal			7	0.03		6							Y			
531+86		Crack Spiral			5	0.03		6	7						Y			
531+86		Crack Spiral			4	0.01		5	6	Healed				Y				
531+93		Crack Longitudinal			7	0.03		6							Y			

24 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 24

Inspection		Code	Value					Circumferential* (Orientation is looking upstream)		Note 1: Cementitious Mortar Fill or Repair * Active Water Leakage	WP1 - All joints shall be sealed WP2 - All joints shall be sealed SS3 - All pipe sections shall be grouted							
Start	End	Description	Feet			ft. / in.		At / From	To	Remarks	WP1 Urethane	WP2 Acrylamide	SS3 Cement	WP4 Crystal	WP5 Acrylic	WP6 Epoxy	WP7 Sheet	Note 1 Mortar
			Dia	H	L	W	D											
531+96		Crack Longitudinal			7	0.01		6		Healed				Y				
531+97		Crack Longitudinal			7	0.025		6							Y			
532+04		Crack Longitudinal			7	0.025		6							Y			
532+04		Crack Longitudinal			7	0.025		6							Y			
532+10		Crack Longitudinal			7	0.01		5		Healed				Y				
532+10		Crack Longitudinal			7	0.01		7		Healed				Y				
532+25		Crack Longitudinal			7	0.01		7		Healed				Y				
532+32		Infiltration Weeper						5	8		*	*						
532+34		Crack Longitudinal			2	0.011		5						Y				
532+34		Crack Longitudinal			2	0.011		7		Healed				Y				
532+39		Crack Longitudinal			7	0.01		7		Healed				Y				
532+39		Infiltration Weeper						7			*	*						
532+61		Joint Separated				2											Y	
532+61		Joint Offset				0.125												
532+61		Surface Damage Surface Spalling						12		At Joint								Y
532+64		Crack Longitudinal			4	0.02		6						Y				
532+82		Infiltration Runner						5		At Joint	*	*						
532+89		Infiltration Weeper						5		At Joint	*	*						
532+96		Joint Separated				1.75											Y	
532+96		Joint Offset				0.5												
533+03		Joint Separated				1.75											Y	
533+03		Joint Offset				0.25												
533+03		Infiltration Runner						7			*	*						
533+03		Infiltration Runner						5			*	*						
533+25		Joint Separated				2											Y	
533+25		Joint Offset				0.5												
533+32		Joint Separated				1.75											Y	
533+39		Joint Separated				2											Y	
533+39		Surface Damage AggregateMissing			2	0.5		4	5									Y
533+46		Joint Separated				1.625											Y	
533+54		Surface Damage Surface Spalling						9										Y
533+34		Survey End																

25 SCOPE OF WORK
WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1

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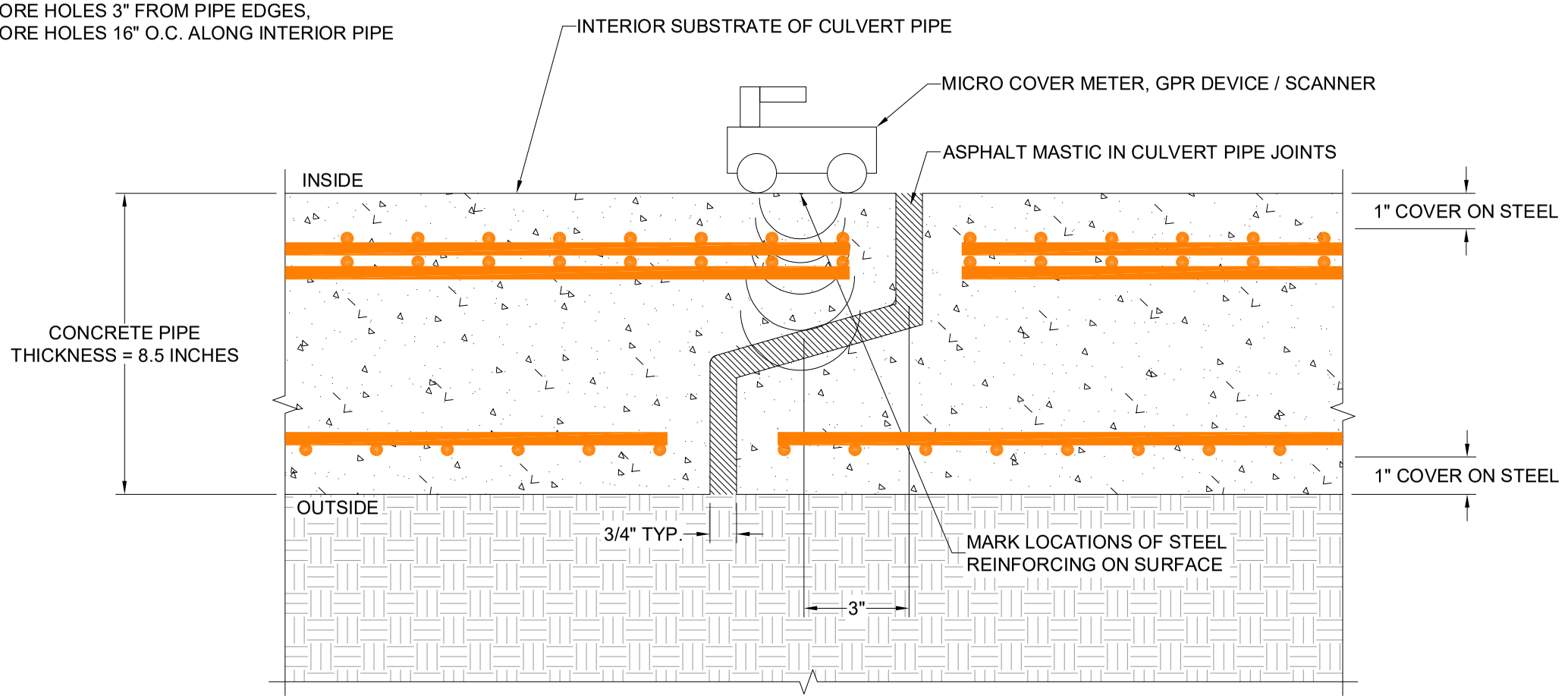
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 25

GENERAL CONDITIONS:

1. COORDINATE SAFETY PLAN TO INCLUDE MANAGEMENT OF MANCHETTE TOPS TO AVOID TRIP HAZARDS TO TRADESMEN
2. COORDINATE ACCESS/EGREE PLAN IN CASE OF HIGH WATER, EXCESS CARBON DIOXIDE, LACK OF LIGHTING AND/OR OTHER ISSUES THAT MAY REQUIRE UNPLANNED EVACUATION OF CULVERT PIPE
3. COORDINATE WORKING TIMES TO ENSURE STORM WATER DRAINAGE DOES NOT INTERFERE WITH GROUTING OPERATIONS BEYOND MANAGED WATER RE-ROUTING
4. ENSURE PROJECT TEAM IS COORDINATED WITH WEATHER FORECASTS AND CURRENT CONDITIONS
5. ENSURE WATER DIVERSION PLAN IS APPROVED BY OWNER
6. FOLLOW ALL OSHA REQUIREMENTS FOR CONFINED SPACE
7. ENSURE:
   - 7.1. PROPER & ADEQUATE LIGHTING & ELECTRICAL SUPPLY
   - 7.2. PROPER & ADEQUATE FRESH AIR-SUPPLY
   - 7.3. PROPER & ADEQUATE AIR QUALITY MONITORING
   - 7.4. PROPER & ADEQUATE EYE WASH STATIONS ARE SETUP
8. IDENTIFY ALL BURIED UTILITIES WITHIN IMMEDIATE GROUT ZONE AREA.
9. IDENTIFY STORM OR SANITARY SEWER PIPES WITHIN 10 FEET OF GROUT ZONE, AND ESTABLISH SOME CRITERIA TO MONITOR EXISTING PIPING DURING CHEMICAL GROUTING TO ENSURE NO STRAY GROUT MIGRATION OCCURS.

1. CLEAN DRY SUBSTRATES IN GROUT ZONE
2. GPR OR EQUAL TO LOCATE STEEL REINFORCING
3. MARK DRILL / CORE LOCATIONS IN CONCRETE SUBSTRATE AS FOLLOWS:
   - 3.1. LOCATE DRILL / CORE HOLES 3" FROM PIPE EDGES,
   - 3.2. LOCATE DRILL / CORE HOLES 16" O.C. ALONG INTERIOR PIPE CIRCUMFERENCE



1 POLYURETHANE GROUT, JOINT INJECTION
GENERAL CONDITIONS, LOCATION OF STEEL REINFORCEMENT

Scale 1-1/2"=1'-0"

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GENERAL NOTES:			
1. STEEL REINFORCING VARIES AT LOCATIONS IN CULVERT PIPE.			

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RAYMOND ROAD CULVERT PIPE RESTORATION

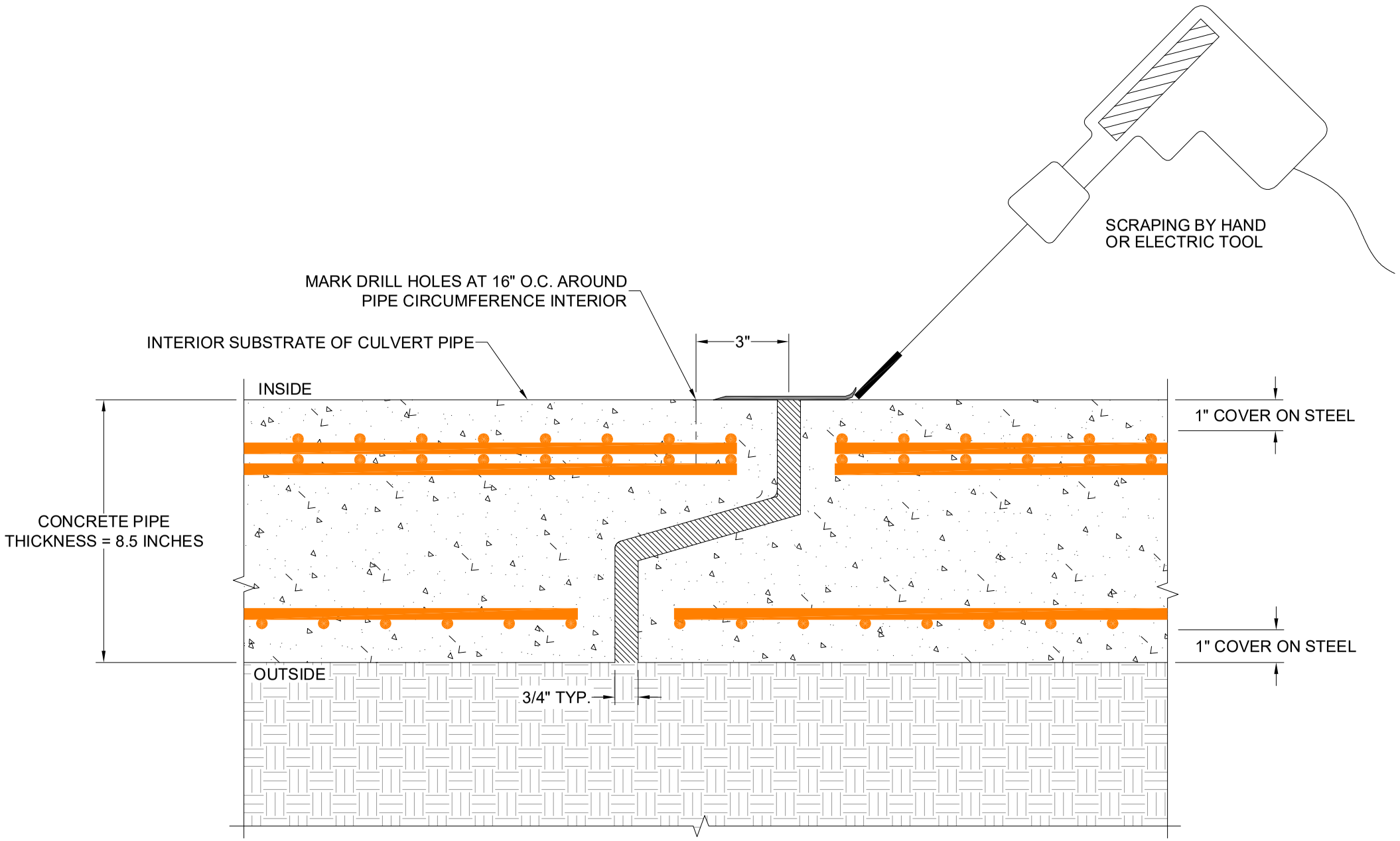
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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

SHEET: 1A

1. CLEAN EXCESS ASPHALT JOINT COMPOUND FROM PIPE FLANGE AREA
2. ENSURE ORIENTATION OF PIPE FLANGE JOINT IS KNOWN



2 POLYURETHANE GROUT, JOINT INJECTION
JOINT PREPERATION

Scale 1-1/2"=1'-0"

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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CHK	BA	1/9/2020

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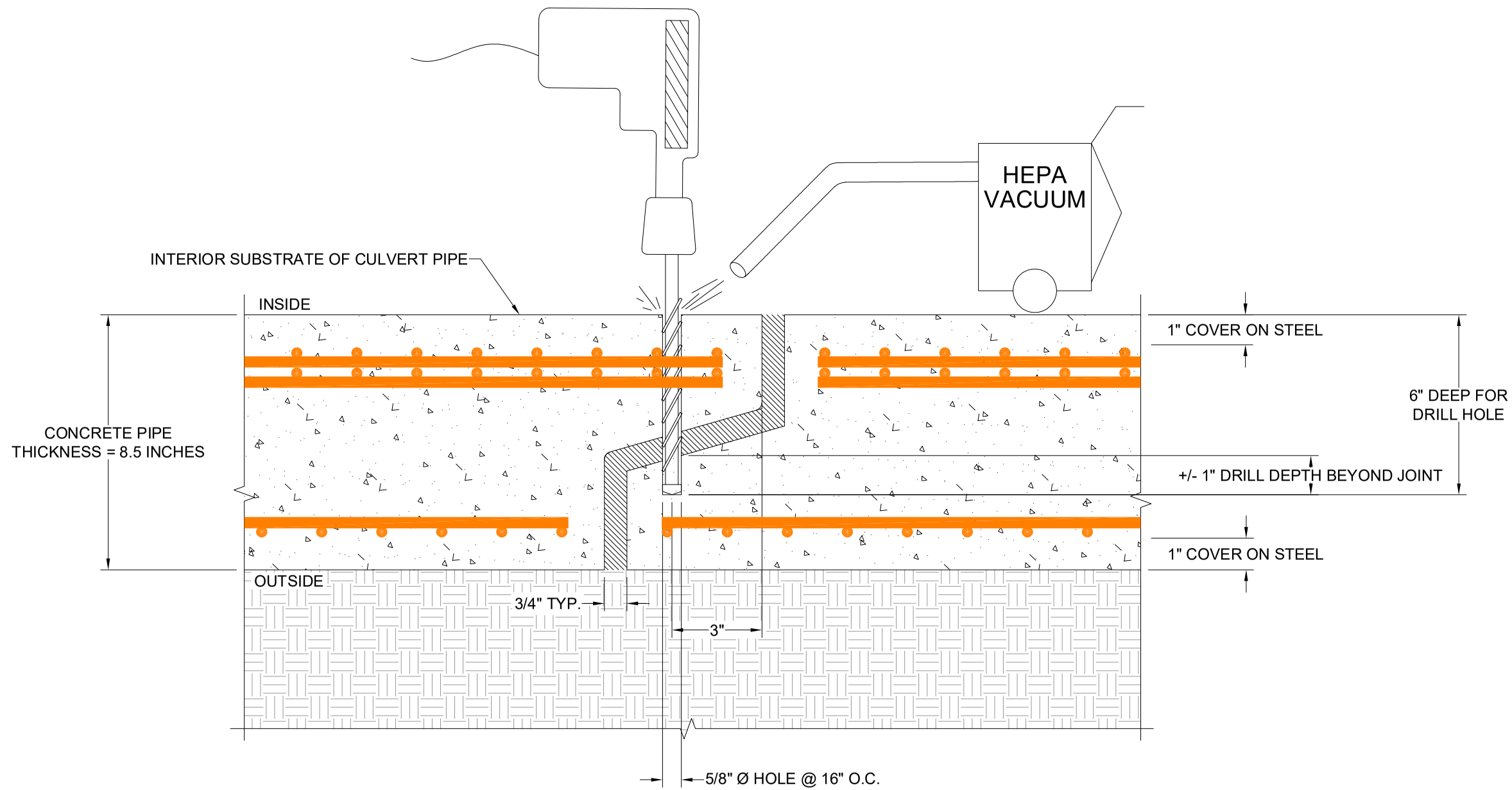
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 2A

1. DRILL / CORE 5/8" Ø HOLE THROUGH CONCRETE PIPE FLANGE 6" DEEP
2. DUST CONTROL PER OSHA REGULATIONS
3. USE HEPA VAC FOR DUST CONTROL WHERE REQUIRED



3 POLYURETHANE GROUT, JOINT INJECTION

MAPPING DRILL HOLES, DRILLING

Scale 1-1/2"=1'-0"

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RAYMOND ROAD CULVERT PIPE RESTORATION

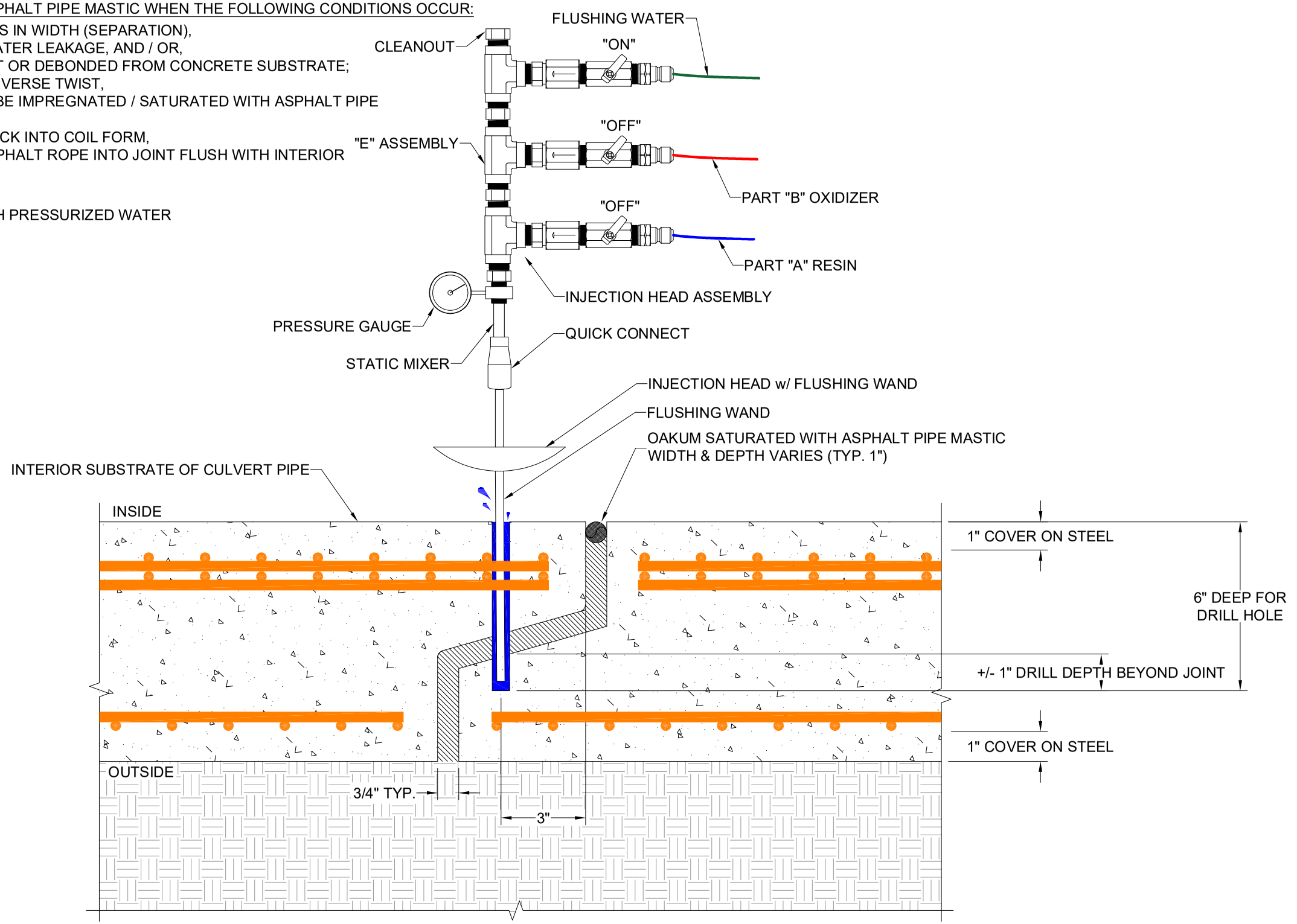
SHEET: 3A

PLACE OAKUM ROPE SATURATED WITH ASPHALT PIPE MASTIC WHEN THE FOLLOWING CONDITIONS OCCUR:

1. THE PIPE JOINT EXCEEDS 1.25 INCHES IN WIDTH (SEPARATION),
2. THE PIPE JOINT SHOWS SIGNS OF WATER LEAKAGE, AND / OR,
3. THE ASPHALT PIPE MASTIC HAS SPLIT OR DEBONDED FROM CONCRETE SUBSTRATE;
   - 3.1. TAKE NON-OILED OAKUM AND REVERSE TWIST,
   - 3.2. UNWRAVELED OAKUM ROPE TO BE IMPREGNATED / SATURATED WITH ASPHALT PIPE MASTIC,
   - 3.3. COIL OAKUM / ASPHALT ROPE BACK INTO COIL FORM,
   - 3.4. POUND AND WEDGE OAKUM / ASPHALT ROPE INTO JOINT FLUSH WITH INTERIOR SURFACE.

NOTE:

1. FLUSH DRILL HOLE / CORE HOLE WITH PRESSURIZED WATER



4 POLYURETHANE GROUT, JOINT INJECTION

DRILL HOLE FLUSHING AND OAKUM PLACEMENT

Scale 1-1/2"=1'-0"

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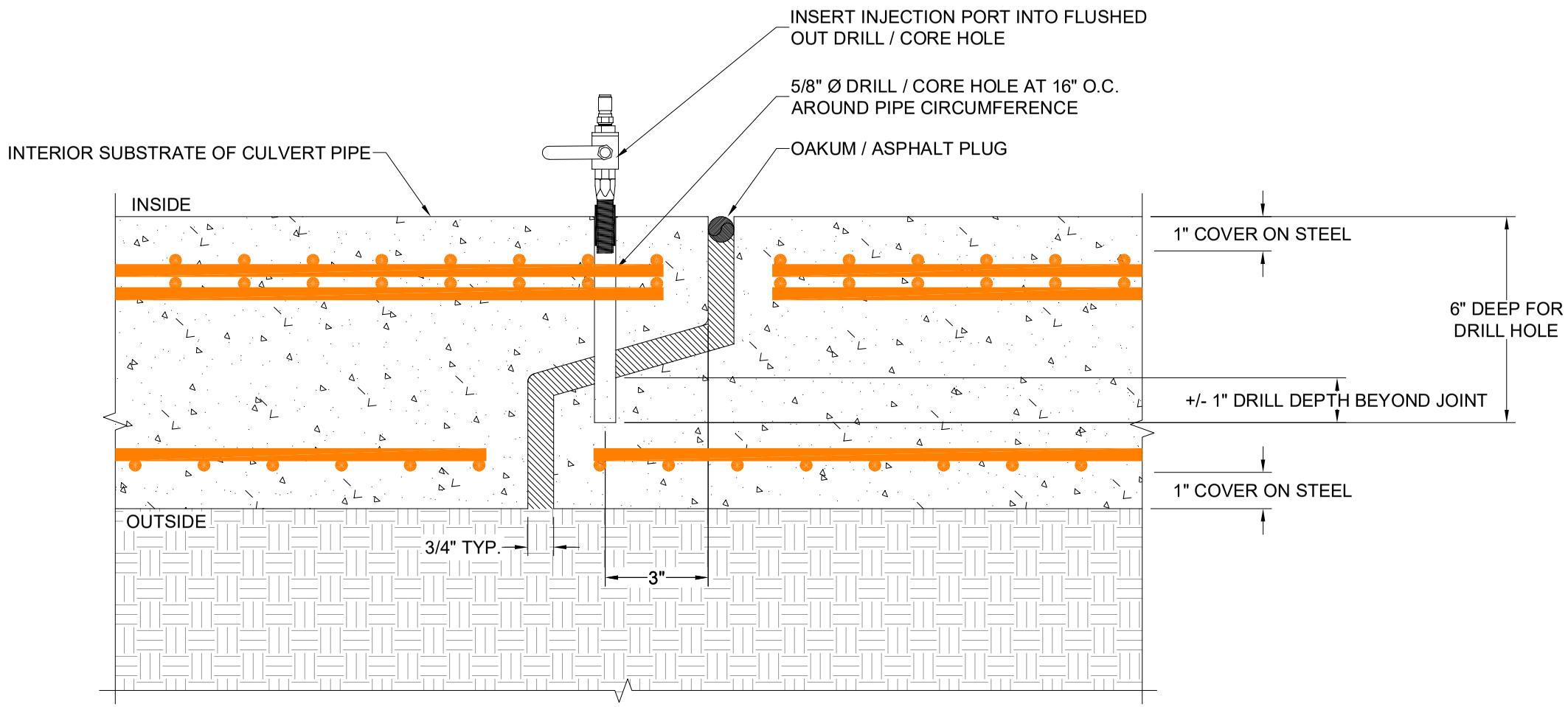
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 4A

1. INSERT INJECTION PORT INTO WATER FLUSHED DRILL / CORE HOLE AT 16" O.C. ALONG PIPE CIRCUMFERENCE
2. USE PLASTIC COUPLER ON TAPERED SHAFT OF PORT / PACKER AND TIGHTEN INTO POSITION



5 POLYURETHANE GROUT, JOINT INJECTION
PLACEMENT OF INJECTION PORT / PACKER

Scale 1-1/2"=1'-0"

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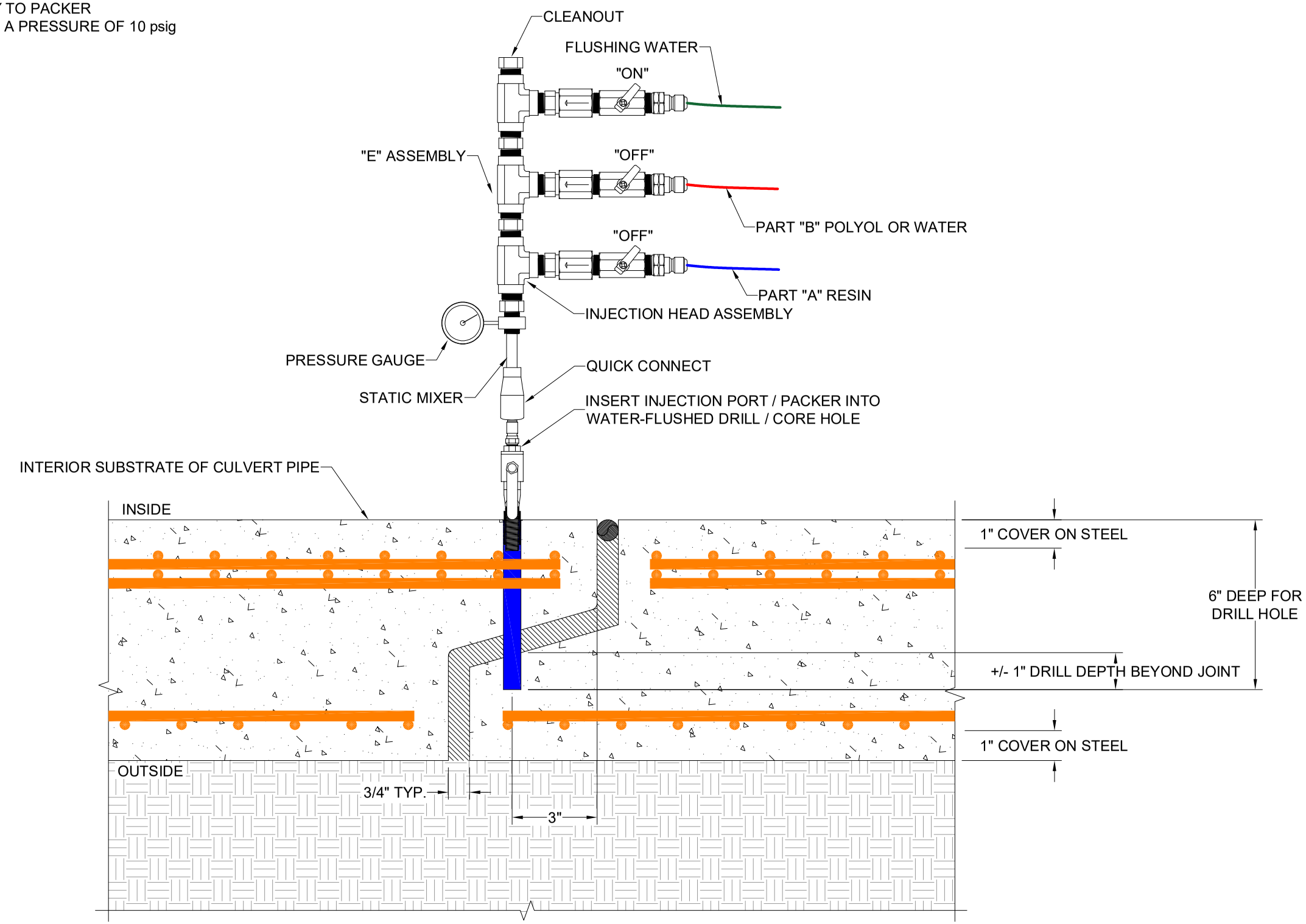
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 5A

1. ATTACH FLUSHING PUMP ASSEMBLY TO PACKER
2. OPEN BALL-VALVE, PUMP WATER TO A PRESSURE OF 10 psig



6 POLYURETHANE GROUT, JOINT INJECTION
WATER TESTING DRILL HOLES, SET-UP

Scale 1-1/2"=1'-0"

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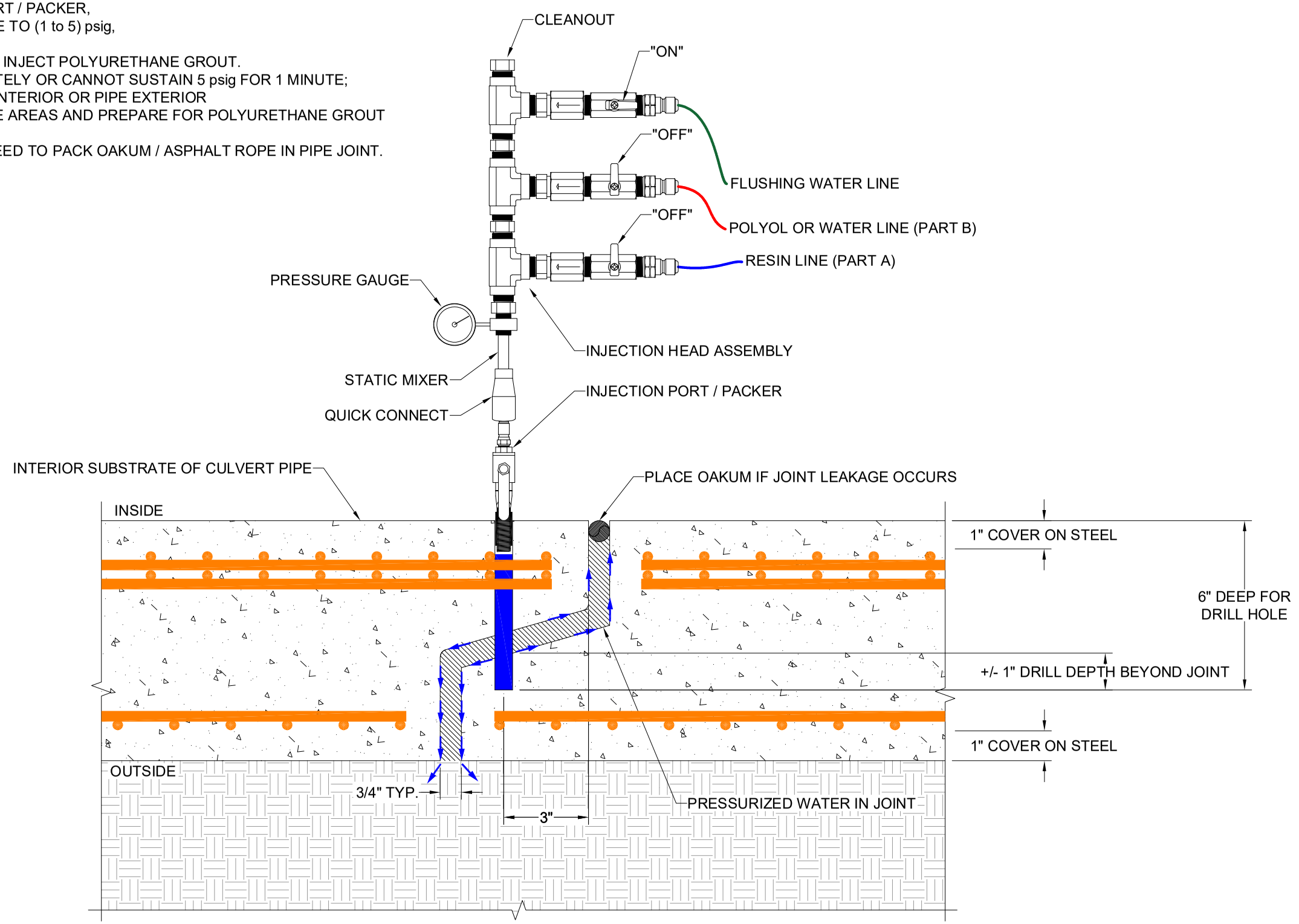
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 6A

1. OPEN BALL-VALVE ON INJECTION PORT / PACKER,
2. PUMP WATER UNDER LOW PRESSURE TO (1 to 5) psig,
3. IF PRESSURE HOLDS AT 5 psig,
   3.1. JOINT IS WATERTIGHT, NO NEED TO INJECT POLYURETHANE GROUT.
4. IF PUMP PRESSURE DROPS IMMEDIATELY OR CANNOT SUSTAIN 5 psig FOR 1 MINUTE;
   4.1. WATER LEAKAGE IS OCCURING AT INTERIOR OR PIPE EXTERIOR
5. NOTE PIPE JOINT EXTERIOR LEAKAGE AREAS AND PREPARE FOR POLYURETHANE GROUT INJECTION.
6. IF PIPE LEAKAGE IS INTERIOR, PROCEED TO PACK OAKUM / ASPHALT ROPE IN PIPE JOINT.



7 POLYURETHANE GROUT, JOINT INJECTION

WATER TEST FOR LEAKAGE RATE, PLACE OAKUM PLUG WHEN REQUIRED

Scale 1-1/2"=1'-0"

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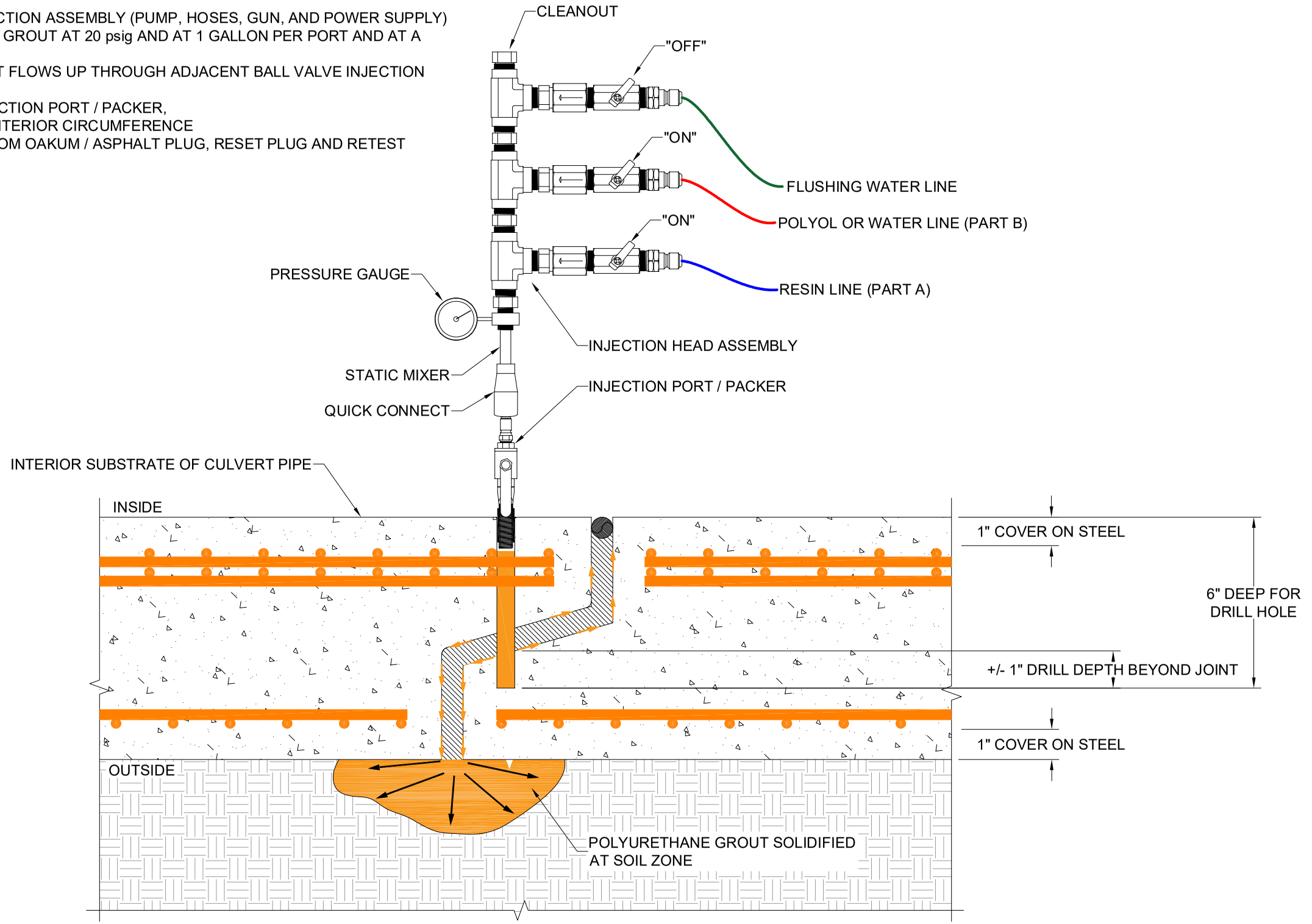
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 7A

1. SETUP POLYURETHANE GROUT INJECTION ASSEMBLY (PUMP, HOSES, GUN, AND POWER SUPPLY)
2. PUMP HYDROPHILIC POLYURETHANE GROUT AT 20 psig AND AT 1 GALLON PER PORT AND AT A RATE OF 1/4 GAL. PER MINUTE
3. IF OR / WHEN POLYURETHANE GROUT FLOWS UP THROUGH ADJACENT BALL VALVE INJECTION PORT / PACKER;
   - 3.1. MOVE TO NEXT BALL VALVE INJECTION PORT / PACKER,
   - 3.2. REPEAT PROCEDURE AROUND INTERIOR CIRCUMFERENCE
4. IF POLYURETHANE GROUT LEAKS FROM OAKUM / ASPHALT PLUG, RESET PLUG AND RETEST



8 POLYURETHANE GROUT, JOINT INJECTION

POLYURETHANE GROUT SET-UP AND INJECTION

Scale 1-1/2"=1'-0"

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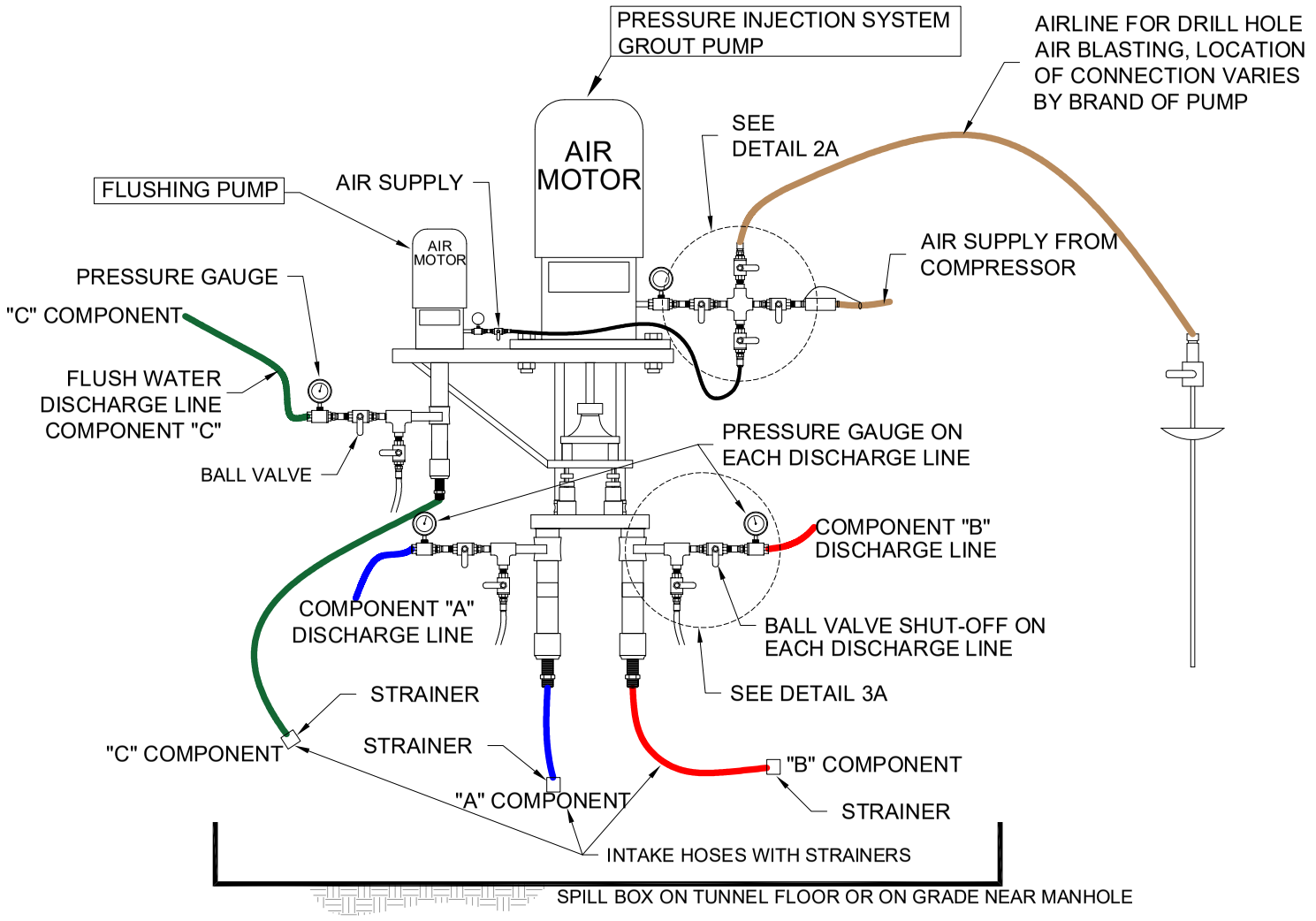
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 8A

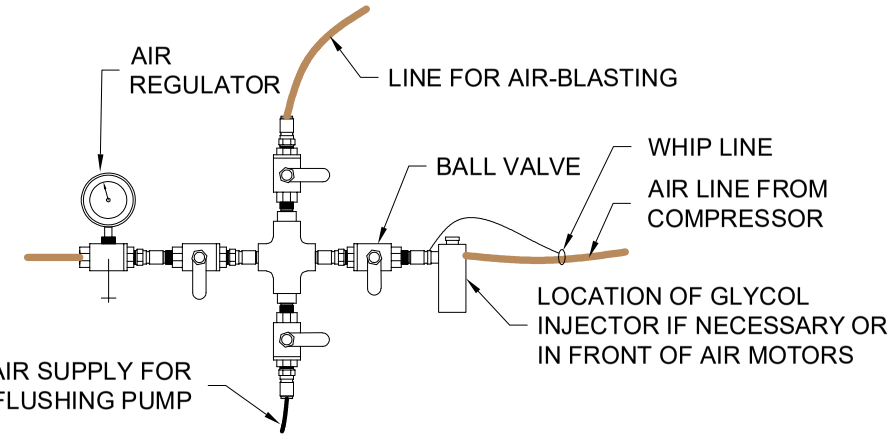
HYDROPHILIC URETHANE GROUT EQUIPMENT AND PROCEDURES:

EQUIPMENT SETUP FOR CHEMICAL GROUT SYSTEM (CGS) - CLEANING, FLUSHING, PRESSURE INJECTION AND STORAGE

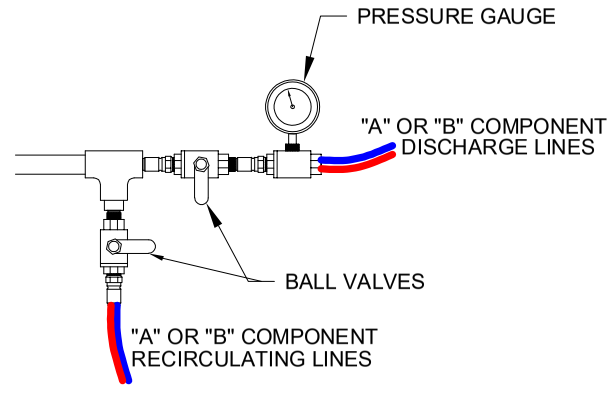


9 POLYURETHANE GROUT, JOINT INJECTION

GROUT & FLUSHING PUMP SET-UP & COMPONENTS



2A DETAIL OF AIR LINE SET-UP



3A DETAIL OF DISCHARGE AND RE-CIRCULATING LINES

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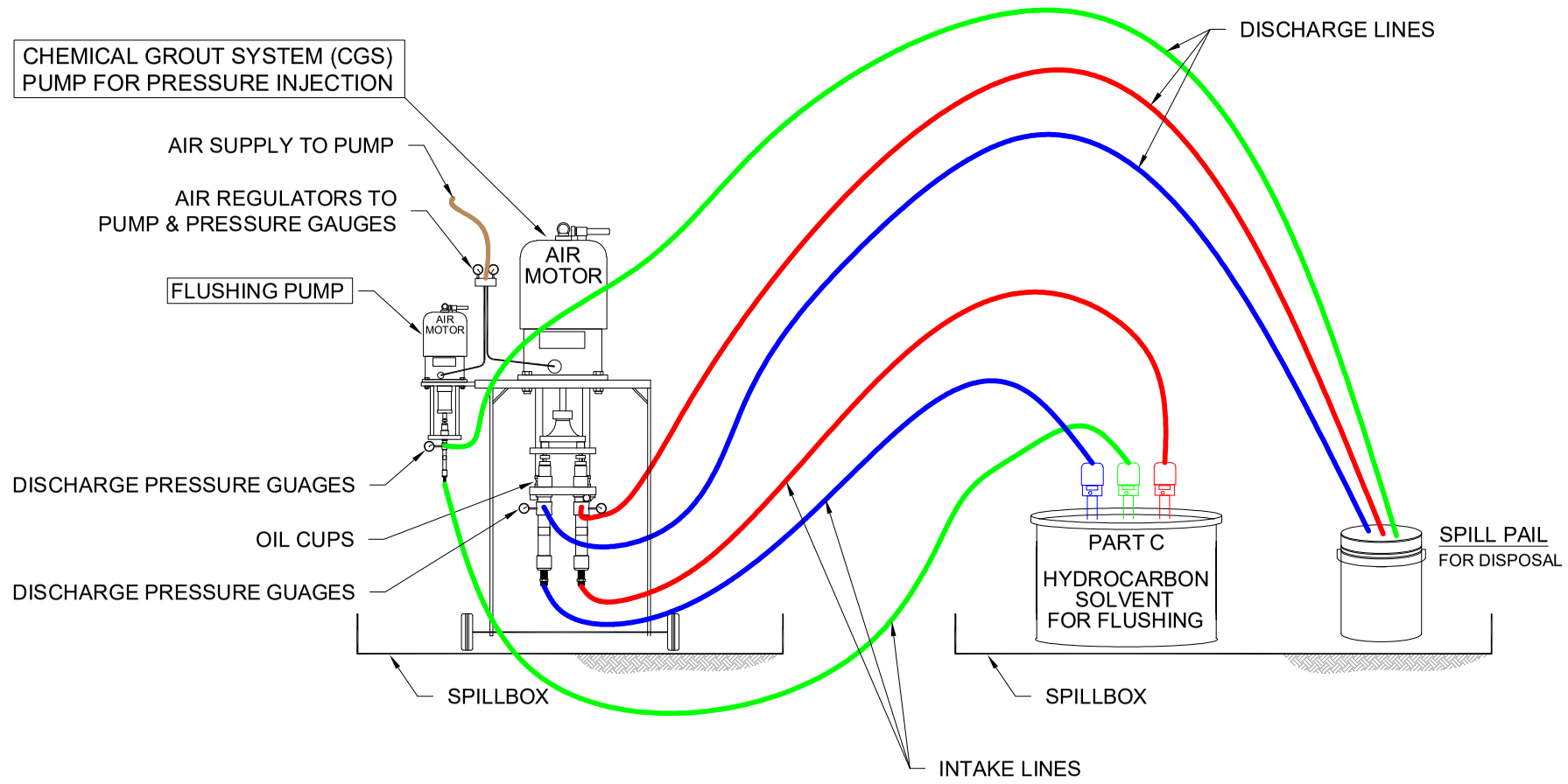
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 9A

1. SET PUMP ON / WITHIN SPILL BOX WITH TEAR RESISTANT MEMBRANE, RAISED ON SIDES
2. ATTACH AIR COMPRESSOR HOSE TO AIR LINE INTAKE ON PRESSURE INJECTION PUMP WITH APPROVED FITTING AND ANTI-WHIP LINE
3. INSTALL ETHYLENE GLYCOL LUBRICATOR IF COLD TEMPERATURES ARE PRESENT OR CONSTANT PUMPING IS REQUIRED
4. FILL PART "C" CONTAINER WITH HYDROCARBON SOLVENT (ACETONE, MEK, TOULENE OR MINERAL SPIRITS), NOTE THESE MATERIALS REQUIRE SPECIAL DISPOSAL PROTOCOL
5. PLACE INTAKE LINE FROM FLUSHING PUMP AND BOTH "A" & "B" COMPONENT PRESSURE INJECTION PUMP LINE OF CHEMICAL GROUT SYSTEM (CGS) INTO PART "C" CONTAINER
6. PLACE ALL THREE DISCHARGE LINES IN SPILL PAIL
7. TURN CHEMICAL GROUT SYSTEM (CGS) PUMP ON AT LOW SPEED AND PRESSURE, ENSURE ALL THREE LINES DISCHARGE LIQUIDS INTO SPILL PAIL
8. CIRCULATE WATER THROUGH SYSTEM UNTIL ALL OIL FROM STORAGE IS FLUSHED OUT OF THE SYSTEM
9. CHECK TO ENSURE RATIO OF "A" & "B" COMPONENTS IS EQUAL OR WITHIN 10% OF EACH OTHER, SEE SHEET 14A
10. PUT INJECTION HEAD ("E" ASSEMBLY) ONTO (USE QUICK CONNECT FITTINGS) DISCHARGE LINES AND CLOSE BALL-VALVES, ENSURE NO LEAKAGE EXISTS AT HIGH FLUID PRESSURE (PRESSURE-CHECK)
11. MAKE ADJUSTMENTS WHERE NECESSARY IF LEAKAGE AT MECHANICAL CONNECTIONS OCCUR



* NOTE:
- RE-CIRCULATING DISCHARGE LINES NOT SHOWN FOR CLARITY
- PUMP IS USUALLY STORED WITH VEGETABLE OIL IN SYSTEM. THIS IS NON-HAZARDOUS AND CAN EASILY BE DISPOSED OF.

10 POLYURETHANE GROUT, JOINT INJECTION
PUMP FLUSHING OF STORAGE OIL OUT FROM SYSTEM
GROUT PUMP PREPERATION

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RAYMOND ROAD CULVERT PIPE RESTORATION

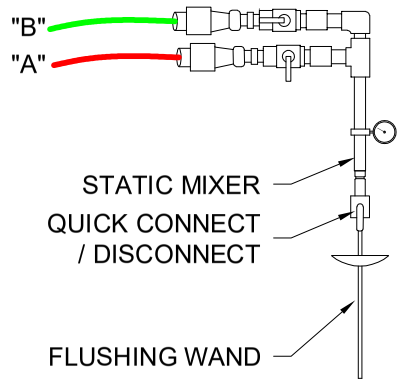
WATER FLUSHING DRILL HOLES WITH SINGLE COMPONENT PUMP:

1. OPEN BALL VALVE ON "L" ASSEMBLY FOR COMPONENT "B", WATER
2. PLACE WATER BLAST WAND ON "E" ASSEMBLY
3. TURN FLUSHING PUMP "ON", ADJUST TO DESIRED WATER BLAST PRESSURE
4. PLACE FLUSHING WAND DOWN DRILL HOLE TO FLUSH DRILLING DEBRIS FROM HOLE

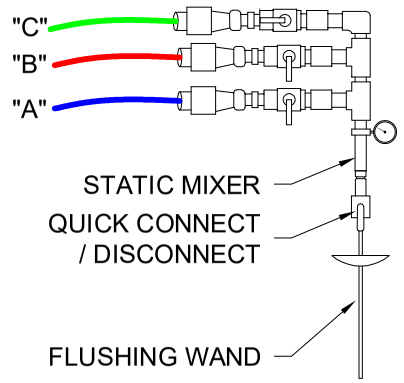
WATER FLUSHING CRACK:

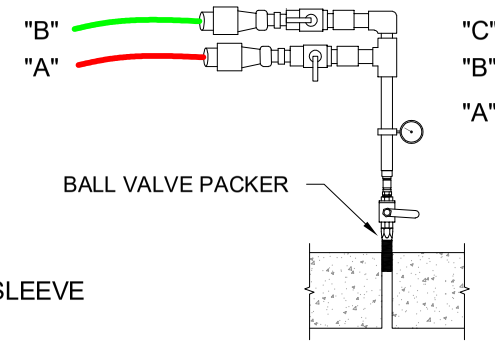
1. REMOVE WATER BLAST WAND FROM "E" OR "L" ASSEMBLY
2. PLACE BALL-VALVE PACKER ON DRILL HOLE, SECURE & TIGHTEN
3. PLACE "E" OR "L" ASSEMBLY ON BALL VALVE PACKER
4. TURN FLUSHING PUMP ON, ADJUST PRESSURE TO ENSURE WATER FLUSHES OUT CRACK 6" ON EACH SIDE OF DRILL HOLE
5. TURN FLUSHING PUMP OFF - REMOVE "E" OR "L" ASSEMBLY FROM PACKER

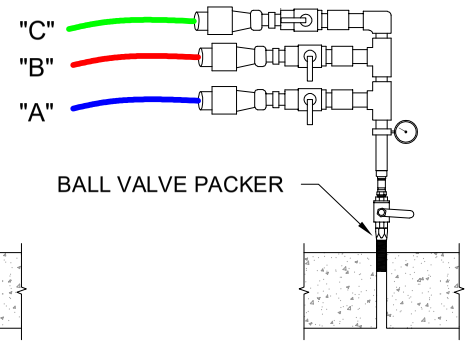
"F" ASSEMBLY

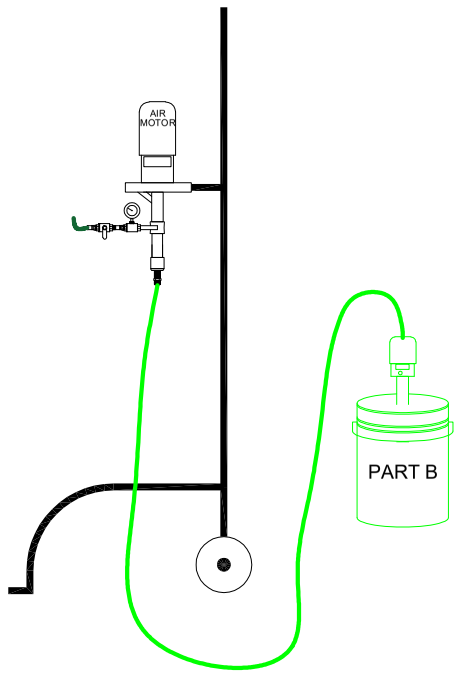


"E" ASSEMBLY

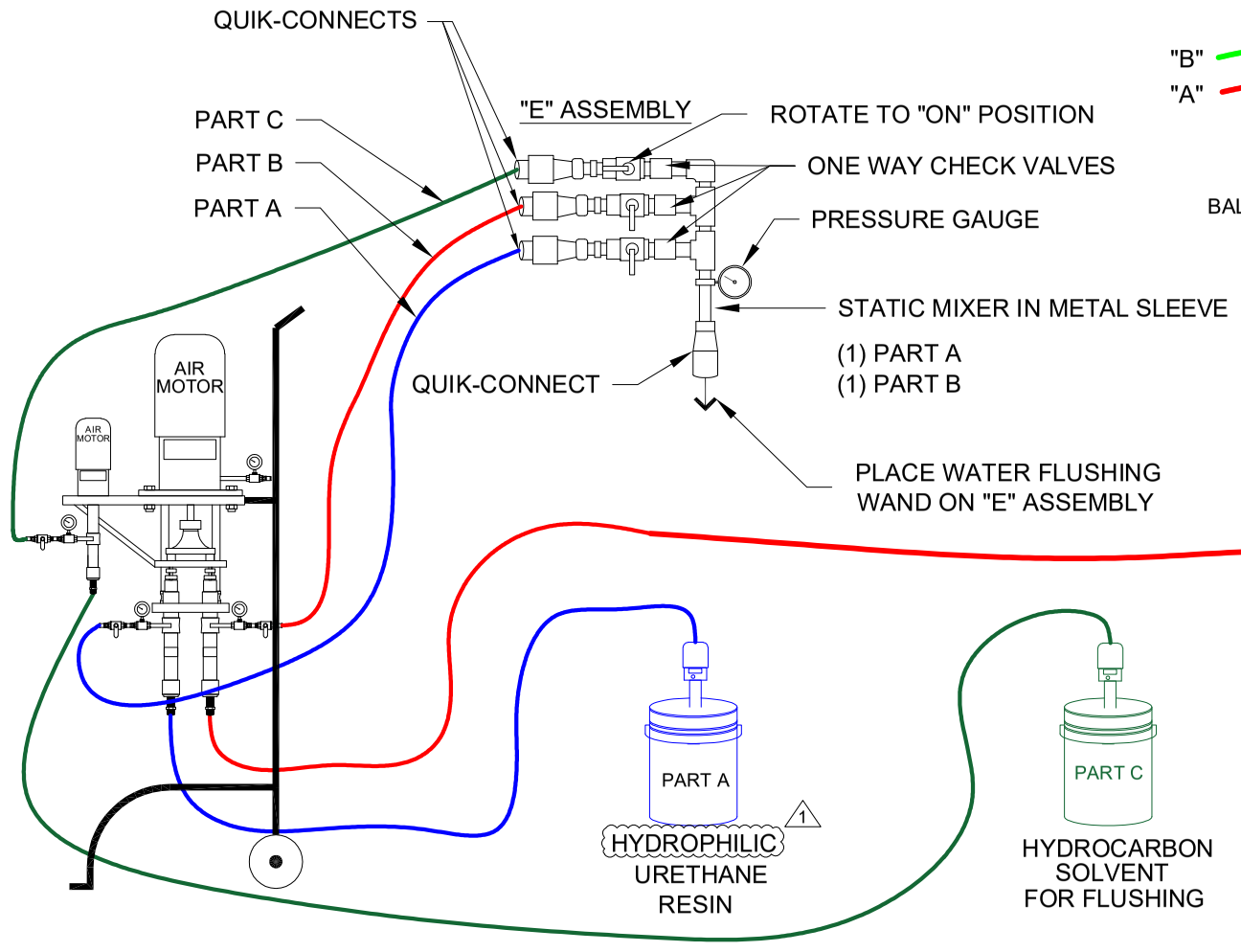






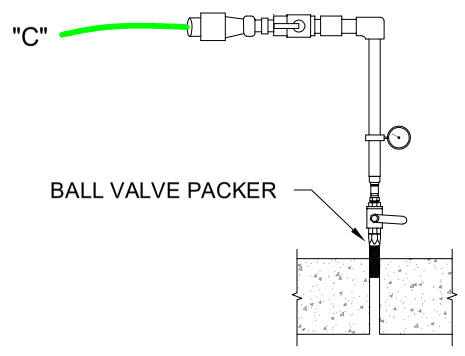


11A SINGLE COMPONENT PUMP
FOR OPTIONAL FLUSHING



11B DUEL COMPONENT PUMP WITH FLUSHING PUMP

"L" ASSEMBLY



11 POLYURETHANE GROUT, JOINT INJECTION
CLASSIC SET-UP FOR FLUSHING GROUT & PUMPING WATER FOR CRACK / JOINT FLUSHING
* NOTE: RE-CIRCULATING LINES NOT SHOWN FOR CLARITY
* NOTE: SPILL BOX NOT SHOWN FOR CLARITY

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RAYMOND ROAD CULVERT PIPE RESTORATION

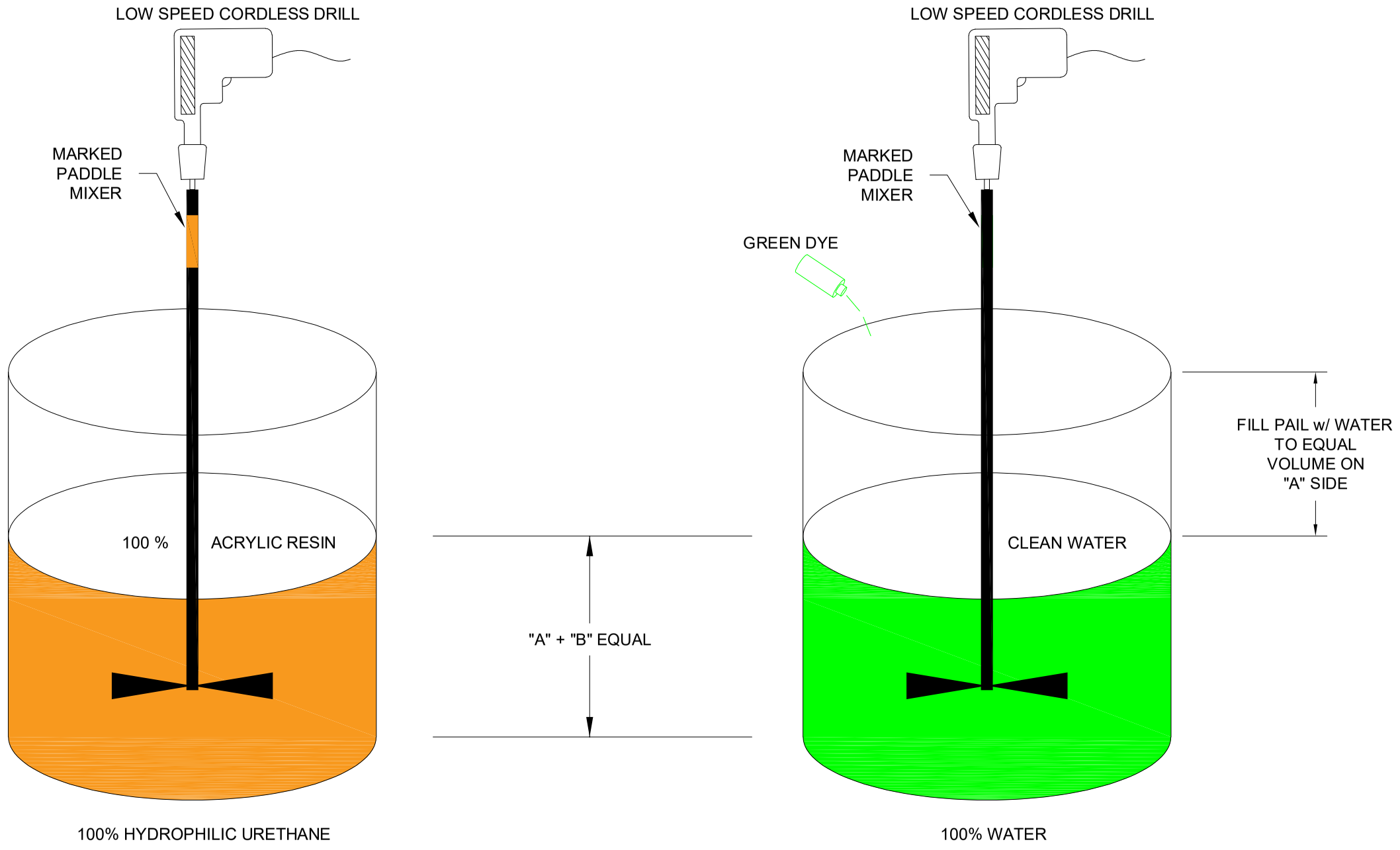
SHEET: 11A

"A" COMPONENT MIXING

1. POSITION 100% HYDROPHILIC URETHANE PAIL ON SPILL PAD
2. OPEN LID ON PAIL
3. PLACE PADDLE IN "A" PAIL AND SLOWLY MIX FOR 2 MINUTES
4. MEASURE TEMPERATURE OF "A" COMPONENT
5. HEAT OR COOL IF NECESSARY
6. PLACE LID BACK ON PAIL UNTIL READY FOR USE
7. MARK "A" PADDLE WITH ORANGE LABEL OR TAPE TO ENSURE AGAINST CROSS-CONTAMINATION IN "B" COMPONENT

"B" COMPONENT MIXING

1. POSITION WATER PAIL AND FILL WITH 4 GALLONS OF CLEAN WATER
2. ADD 2-3 TEASPOONS OF GREEN DYE TO PAIL
3. PLACE PADDLE IN "B" WATER PAIL AND SLOWLY MIX FOR 2 MINUTES
4. MEASURE TEMPERATURE OF "B" COMPONENT FLUID
5. HEAT OR COOL IF NECESSARY
6. PLACE LID BACK ON PAIL UNTIL READY FOR USE
7. MARK "B" RESIN PADDLE WITH GREEN LABEL OR TAPE TO ENSURE AGAINST CROSS-CONTAMINATION IN "A" COMPONENTS
8. FILL PAIL TO AN EQUAL VOLUME AS ON "A" SIDE



100% HYDROPHILIC URETHANE

100% WATER

12 POLYURETHANE GROUT, JOINT INJECTION
MIXING / FORMULATING A&B COMPONENTS

12A "A" COMPONENT MIXING
"A" HYDROCARBON URETHANE PAIL

12B "B" COMPONENT MIXING
"B" WATER PAIL

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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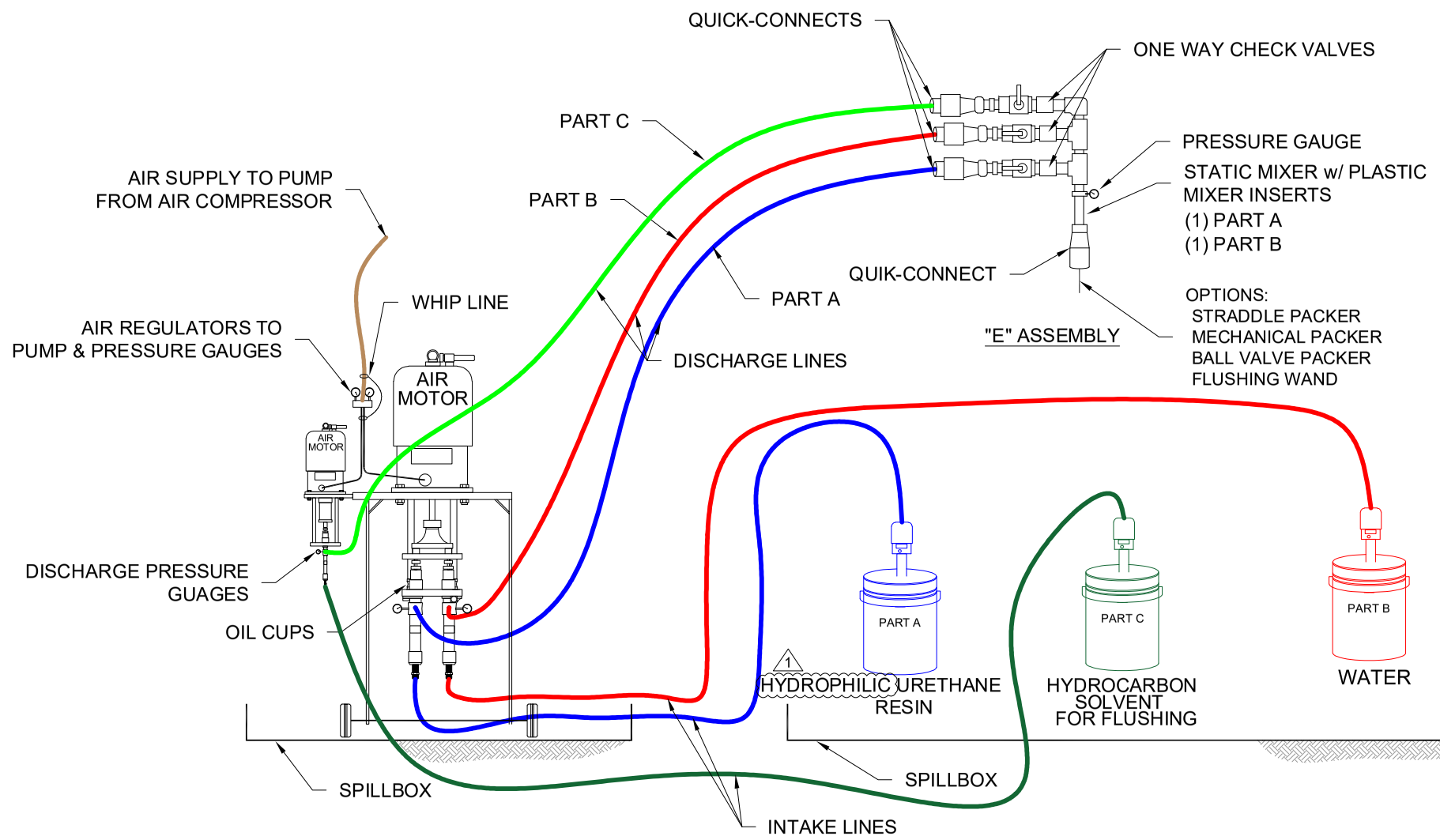
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 12A

1. REFER TO SHEET 14A AND 15A, FOR GEL-TIME CUP TEST, AND RATIO CHECK
2. NOTE: STATIC MIXER NEEDS TO BE FLUSHED WITH SOLVENT PRIOR TO GEL-TIME REACTION
3. TURN ON AIR PRESSURE TO CHEMICAL GROUT SYSTEM PUMP, TURN OFF AIR PRESSURE TO FLUSHING PUMP
4. REGULATE AIR PRESSURE TO OBTAIN A STEADY FLOW OF MATERIAL THROUGH INJECTION GUN*
5. HOOK UP INJECTION HEAD* TO QUICK CONNECT OF BALL VALVE PACKER ASSEMBLY
6. START INJECTION PRESSURE AT (1-5) psig, MONITOR PISTONS ON PUMP FOR FLOW
7. CONTINUE PUMPING UNTIL MIXED GROUT EXTENDS HALF WAY TO EACH ADJACENT PORT
8. IF RESISTANCE TO CHEMICAL GROUT FLOW DOES NOT ALLOW PISTON MOVEMENT, INCREASE PRESSURE TO AIR MOTOR ON CHEMICAL GROUT SYSTEM (CGS) PRESSURE INJECTION PUMP IN 100 psig INCREMENTS UNTIL FLOW OCCURS
9. DO NOT EXCEED 10 psig AT DISCHARGE PRESSURE GAUGES
10. IF CHEMICAL GROUT DOES NOT CONTINUE TO FLOW, REMOVE "E" ASSEMBLY FROM PACKER, FLUSH LINE WITH WATER, REPEAT PROCESS OF DRILLING NEW DRILL HOLE IN VICINITY OF "DEAD HOLE". NOTE THAT THIS SHOULD NOT OCCUR BECAUSE THE HOLE WAS TESTED WITH WATER PREVIOUSLY.
11. MOVE TO NEXT PACKER ASSEMBLY.

* INJECTION GUN = INJECTION HEAD = "E" ASSEMBLY



13 POLYURETHANE GROUT, JOINT INJECTION

CHEMICAL GROUT INJECTION OPERATION AND PLUMBING
* NOTE - RE-CIRCULATING DISCHARGE LINES NOT SHOWN FOR CLARITY

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RAYMOND ROAD CULVERT PIPE RESTORATION

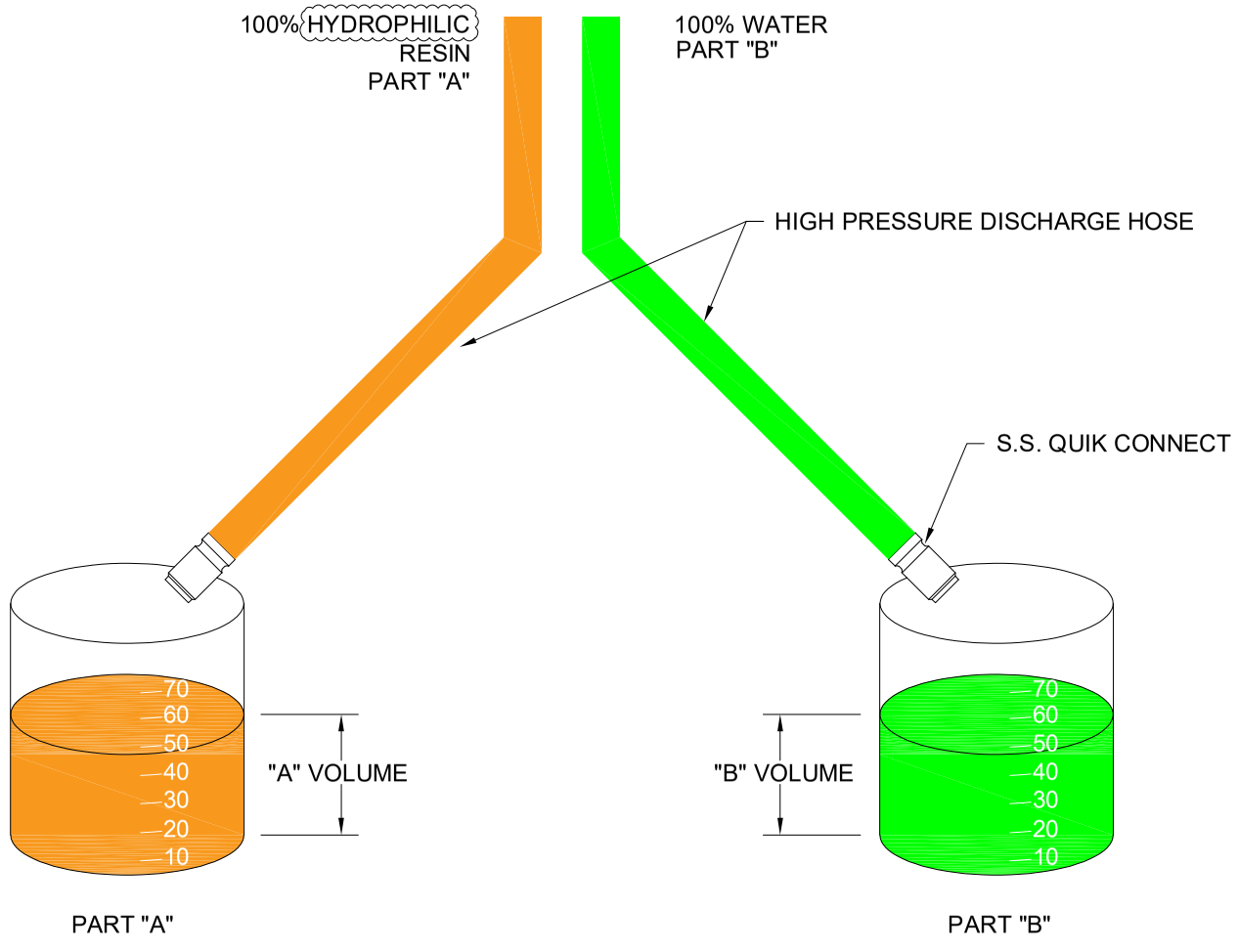
SHEET: 13A

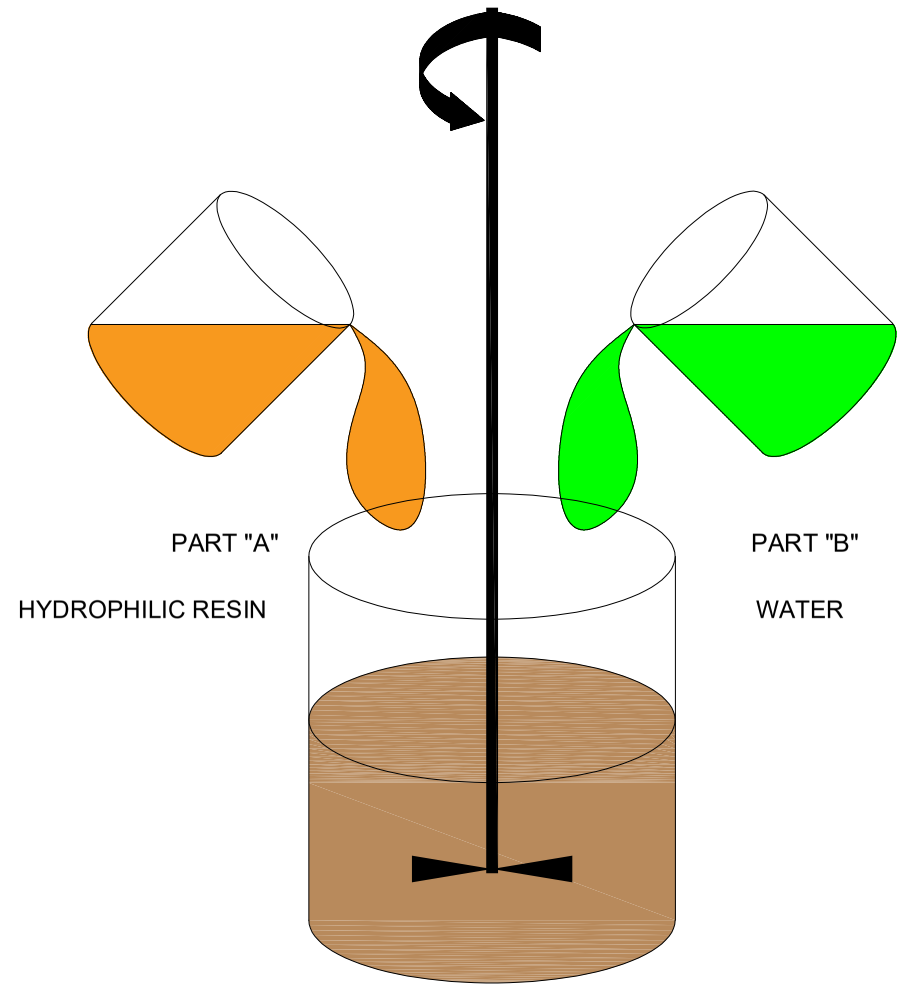
1. PRIOR TO PUMPING:
   1.1. DISCONNECT "E" OR "F" ASSEMBLY
   1.2. PUMP PARTS "A" & "B" INTO MEASURING CUPS TO ENSURE PROPER 1-TO-1 RATIO, TOLERANCE MAY BE 10% EITHER WAY
   1.3. ADJUST PUMP STROKE LENGTH IF NOT IN RATIO OF 1-TO-1
2. RATIO BALANCE CAN BE INFLUENCED BY PARTICLES OR DEBRIS BUILD UP IN VALVES OF PUMP

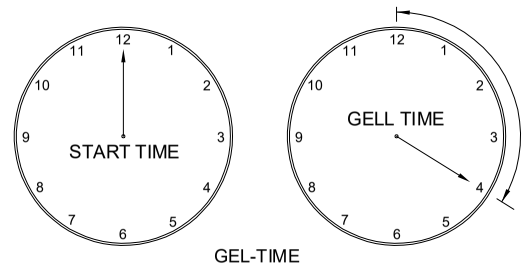
GEL TIME INFLUENCED BY:

1. TEMPERATURE OF LIQUIDS "A" & "B"
2. pH OF WATER ON "B" SIDE
3. IRON CONTENT IN WATER IN "B" SIDE

1. TAKE "A" & "B" COMPONENTS AND MIX TOGETHER, NOTE START TIME.
2. AFTER SHORT PERIOD (30 SECONDS TO 3 MINUTES) GROUT VISCOSITY INCREASES AND SHOULD START TO FOAM.
3. RATHER QUICKLY GROUT SOLIDIFIES INTO A FOAM MASS. NOTE GEL SET TIME.
4. IF GEL TIME IS TOO SHORT:
   4.1. REDUCE PART "A" RESIN BY 20°F INTO PART "A"
   4.2. REDUCE WATER TEMPERATURE IN PART "B" BY 20°F.
   4.3. MEASURE NEW GEL TIME.
5. IF GEL TIME IS TOO LONG:
   5.1. INCREASE TEMPERATURE BY 20° F INTO PART "A"
   5.2. INCREASE TEMPERATURE IN PART "B" BY 20°F
   5.3. MEASURE NEW GEL TIME
6. GEL-TIME IS INFLUENCED BY FLUID TEMPERATURE "A" & "B" RESIN TEMPERATURE CAN BE VARIED FROM 40° F TO 120° F.
7. PAIL AND/OR DRUM HEATERS ARE COMMONLY USED IF WARMING IS REQUIRED.







14 POLYURETHANE GROUT, JOINT INJECTION
RATIO AND GEL-TIME CHECK

14A QA / QC, T-to-1 RATIO CHECK

14B GEL TIME CHECK

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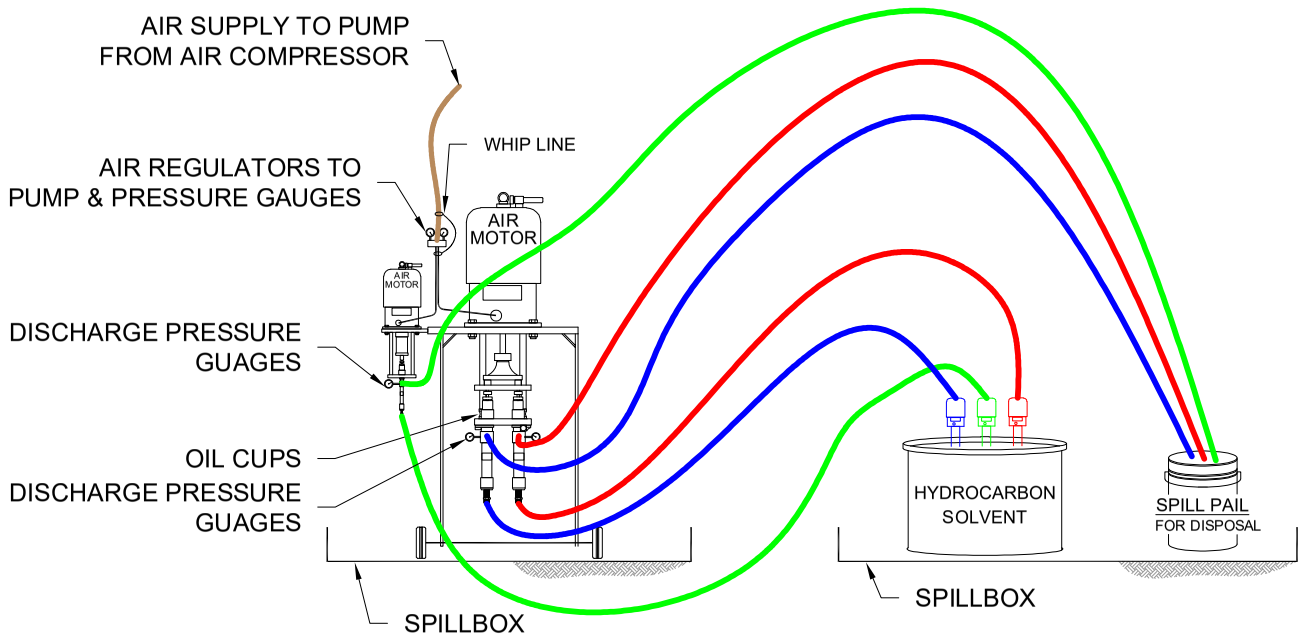
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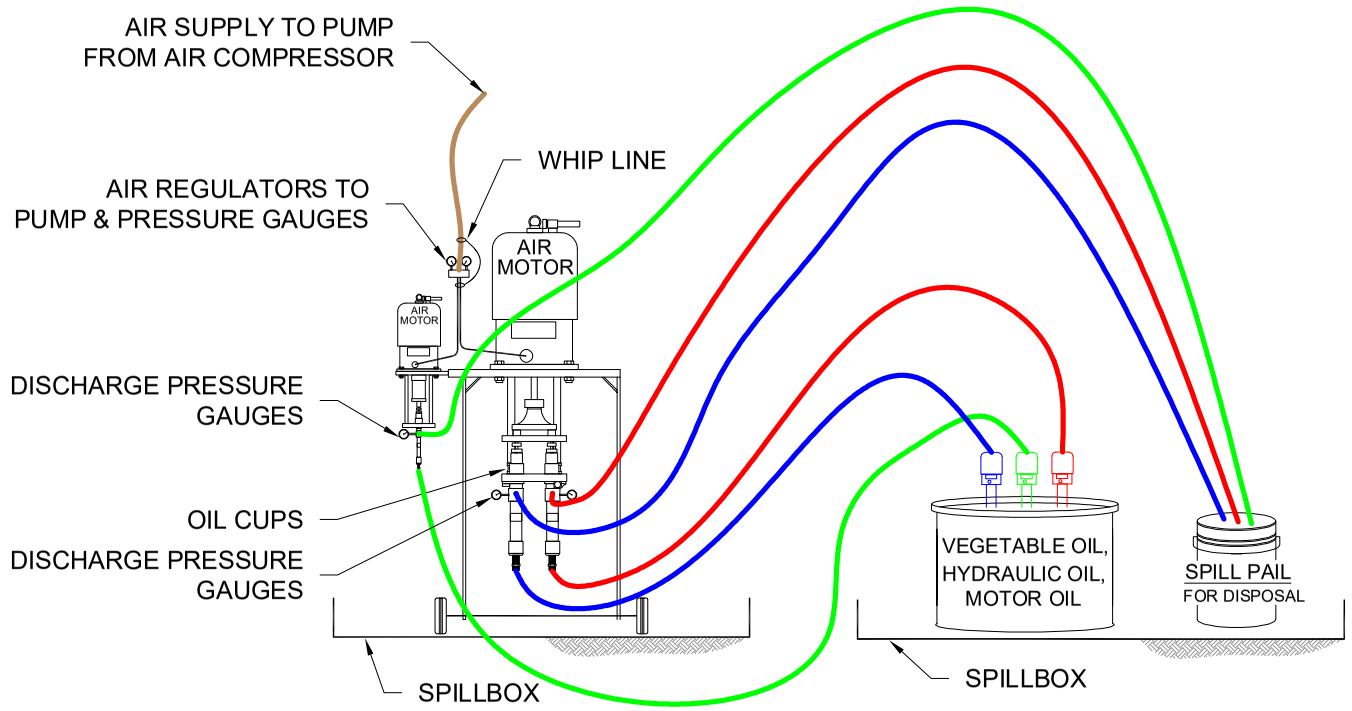
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 14A

1. UPON COMPLETION OF PRESSURE INJECTION OPERATIONS, FLUSH PUMPS (CHEMICAL GROUT SYSTEMS (CGS) PRESSURE INJECTION PUMP AND ATTACHED FLUSHING PUMP) WITH HYDROCARBON SOLVENT INTO SPILL PAIL.
2. DISPOSE OF HAZARDOUS WASTE SOLVENT COMPONENTS.



1. AFTER FLUSHING, PUMP VEGETABLE, OR MOTOR OIL IN (CHEMICAL GROUT SYSTEMS (CGS) PRESSURE INJECTION PUMP AND ATTACHED FLUSHING PUMP) SYSTEM FOR STORAGE AND UNTIL NEXT USAGE.
2. DISPOSE WASTE IN HAZARDOUS STORAGE CONTAINERS

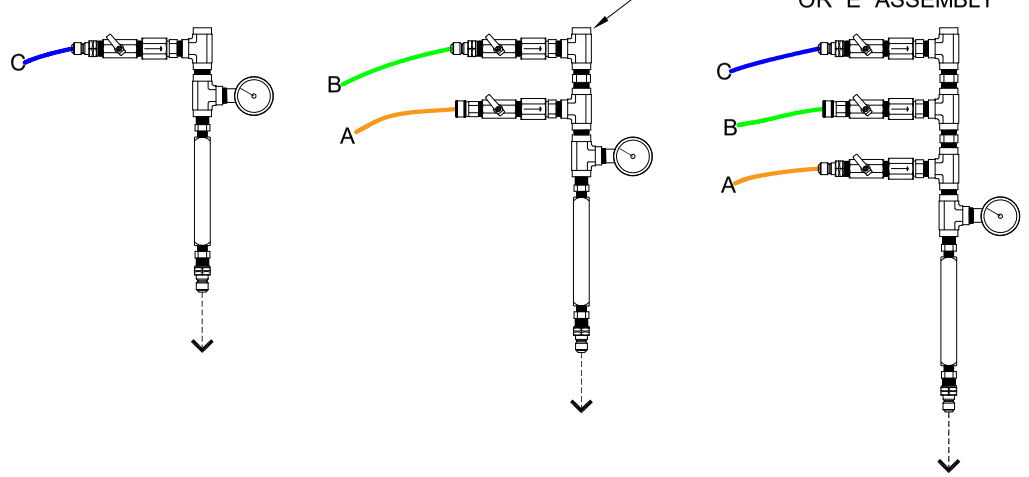


15 POLYURETHANE GROUT, JOINT INJECTION

FLUSHING GROUT PUMP, PREPARING FOR STORAGE AND GROUT PUMP CLEANUP
* NOTE - RE-CIRCULATING DISCHARGE LINES NOT SHOWN FOR CLARITY

WATER FLUSHING LINE IN OPEN POSITION, MEANING PRESSURIZED WATER FLOW TO OCCUR FROM FLUSHING PUMP

CALLED:
INJECTION HEAD
INJECTION GUN
OR "E" ASSEMBLY

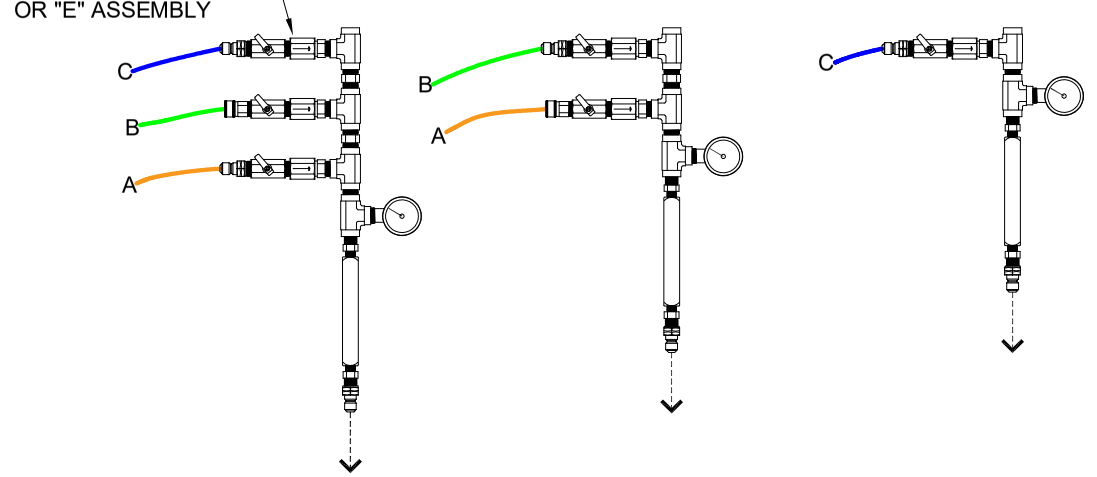


"L" ASSEMBLY "F" ASSEMBLY "E" ASSEMBLY

BALL VALVES, CLOSED POSITION FOR CHEMICAL GROUT FLOW FROM GROUT PUMP

CALLED:
INJECTION HEAD
INJECTION GUN
OR "E" ASSEMBLY

WATER FLUSHING LINE IN CLOSED POSITION, MEANING NO WATER FLOW FROM FLUSHING PUMP



"E" ASSEMBLY "F" ASSEMBLY "L" ASSEMBLY

BALL VALVES, OPEN POSITION FOR CHEMICAL GROUT FLOW FROM GROUT PUMP

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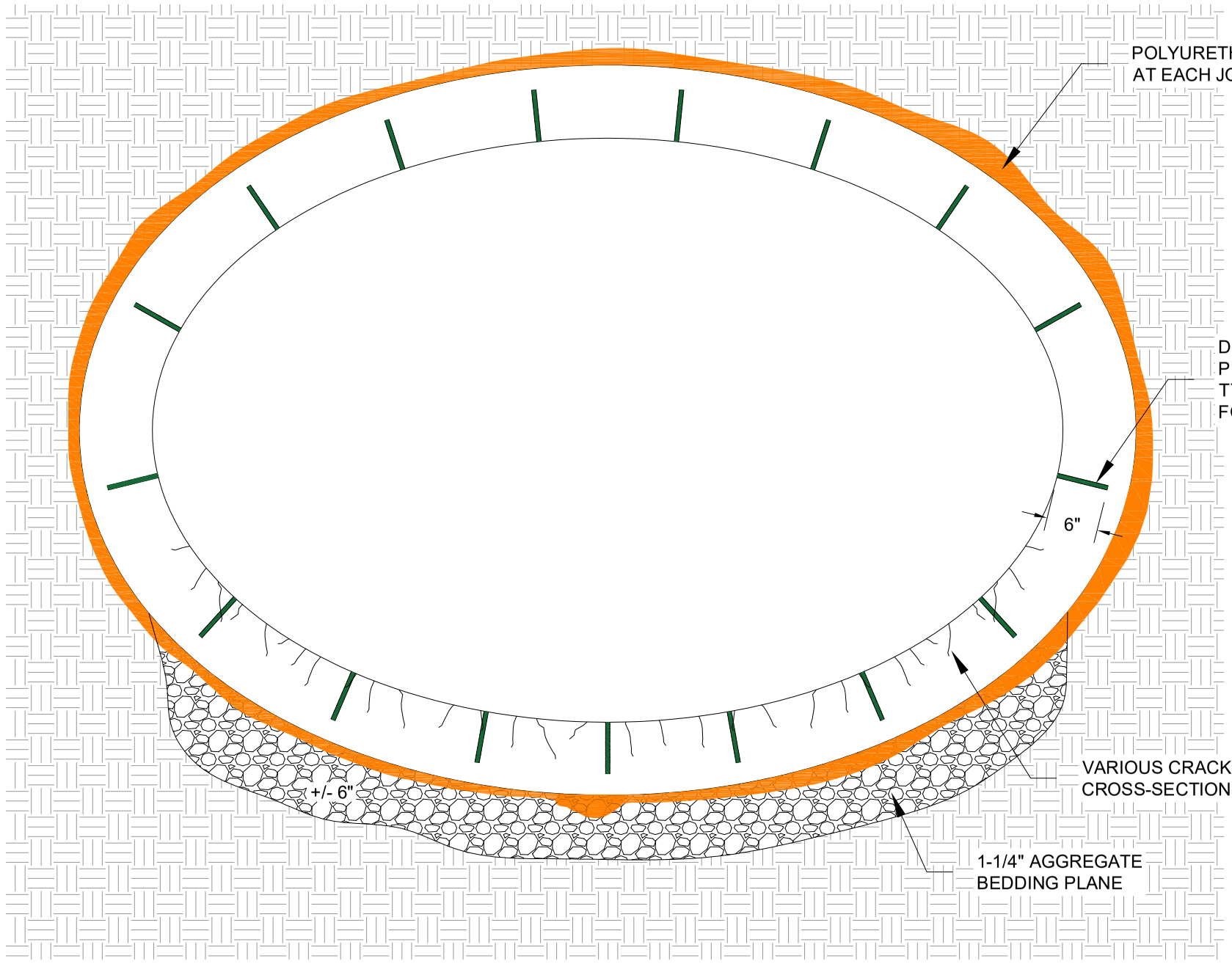
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 15A



16 DRILL HOLE LAYOUT AT +/- 16" O.C. AT CONCRETE PIPE JOINTS

POLYURETHANE GROUT PLUG AROUND PERIMETER OF PIPE JOINTS

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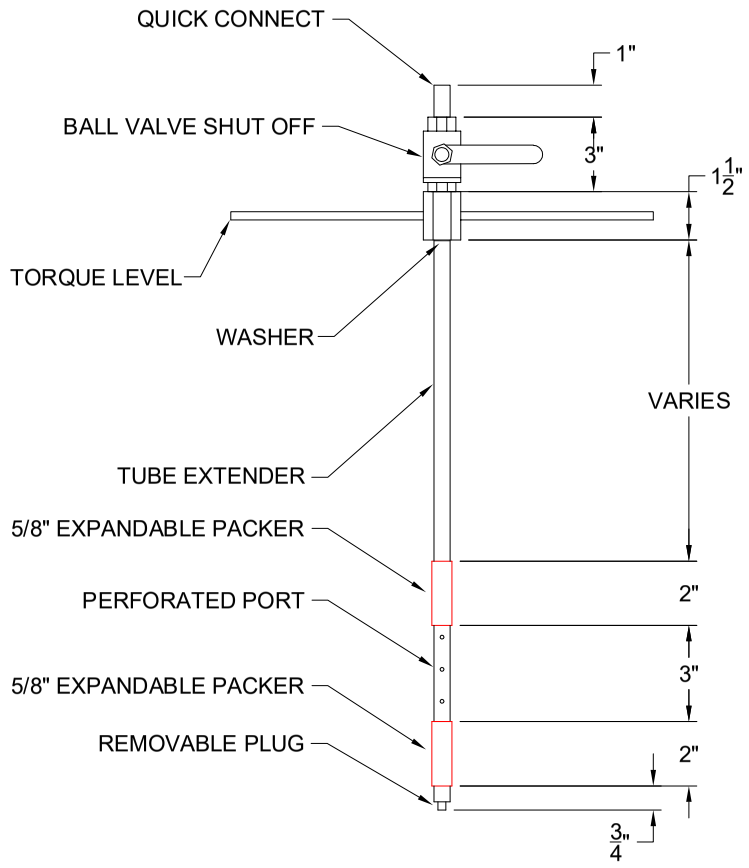
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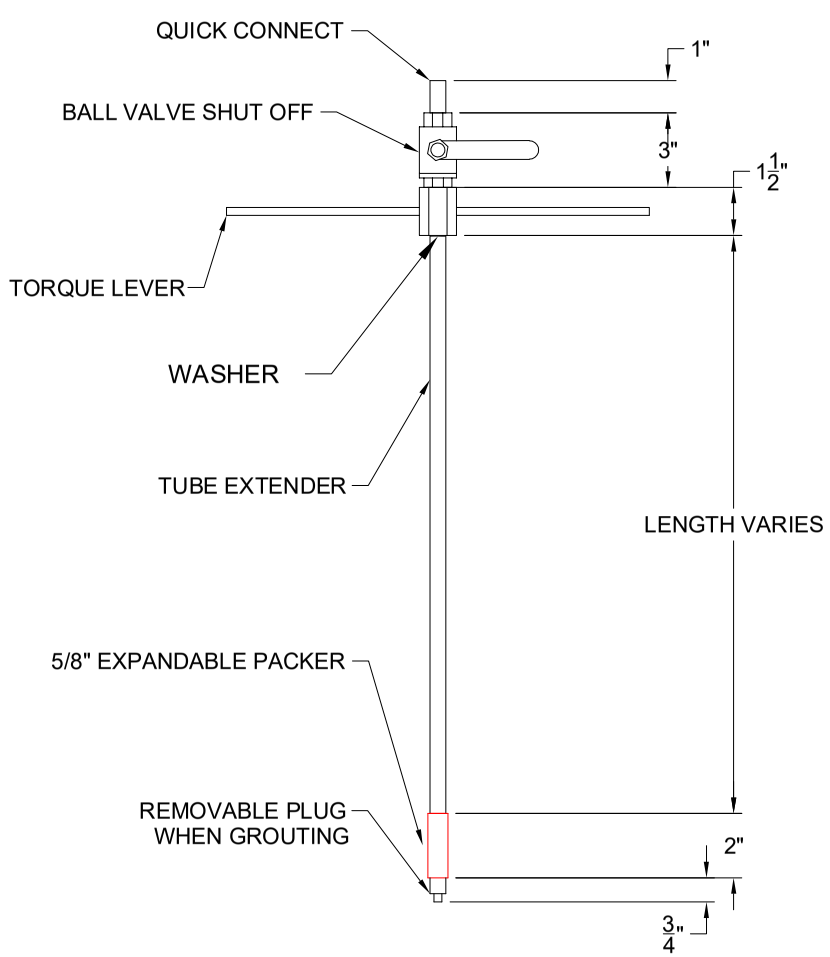
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RAYMOND ROAD CULVERT PIPE RESTORATION

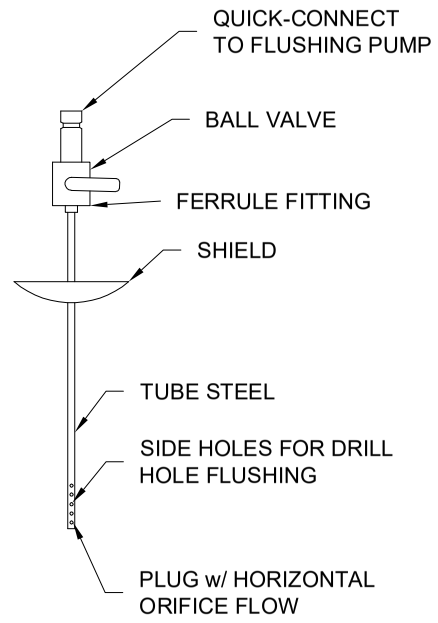
SHEET: 16A



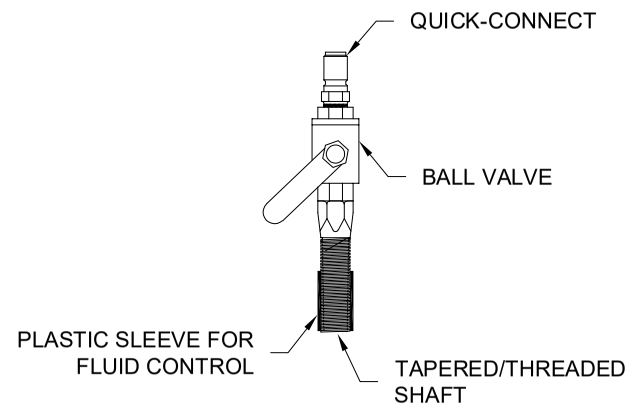
STRADDLE MECHANICAL PACKER



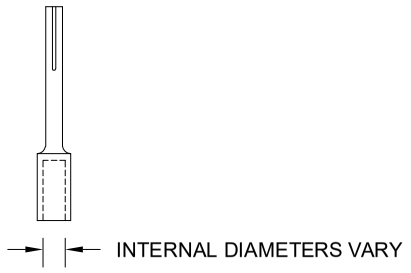
MECHANICAL PACKER



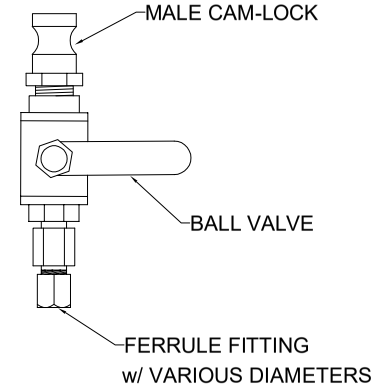
DRILL HOLE FLUSHING WAND



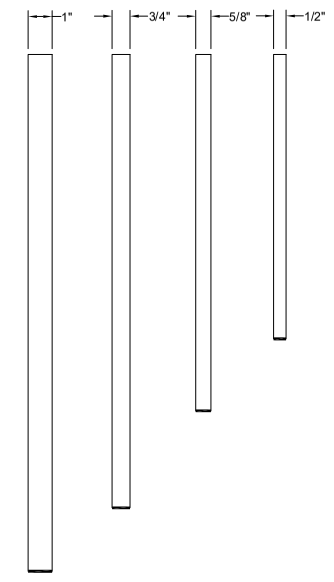
(TSBV) PACKER
TAPERED SHAFT, BALL VALVE (TSBV)



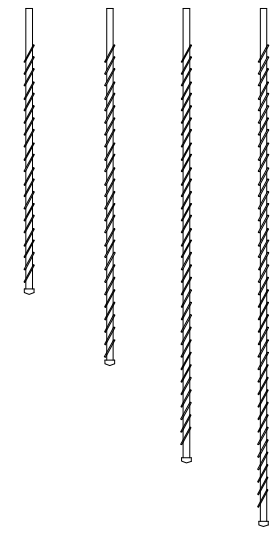
MANCHETTE DRIVER
w/ VARIOUS INTERNAL DIAMETERS



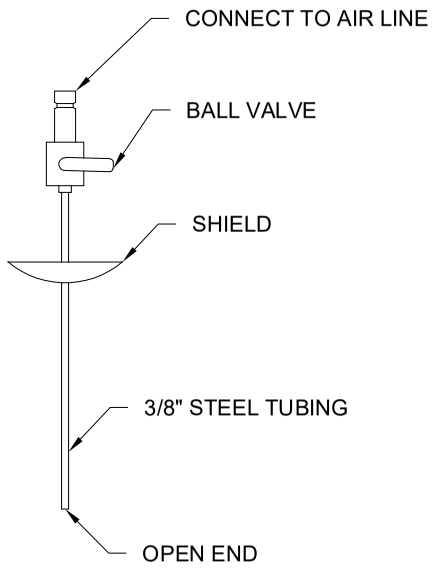
CAM / BALL VALVE / FERRULE



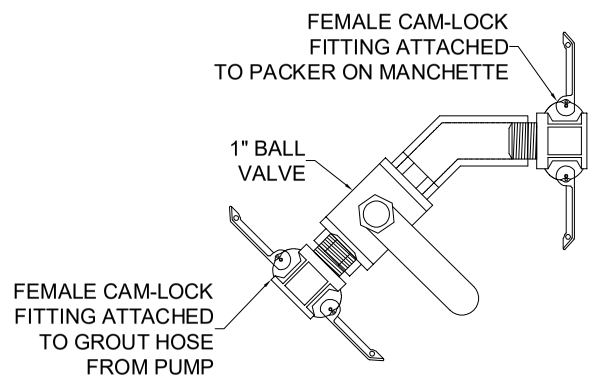
CORE BITS OF VARIOUS
LENGTHS & DIAMETERS



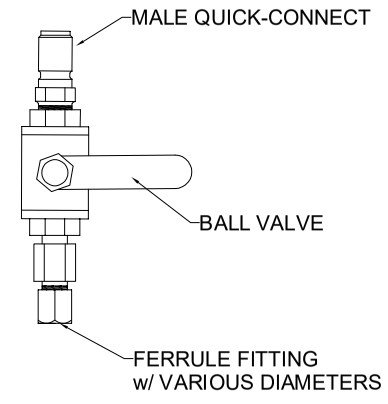
DRILL BITS OF VARIOUS
LENGTHS & DIAMETERS



AIR FLUSHING WAND FOR
INITIAL DRILL HOLE CLEANING



CEMENT GROUT CAM-LOCK INJECTION GUN



QUICK-CONNECT / BALL VALVE / FERRULE

17 POLYURETHANE GROUT, JOINT INJECTION
EXAMPLES OF GROUTING ACCESSORIES

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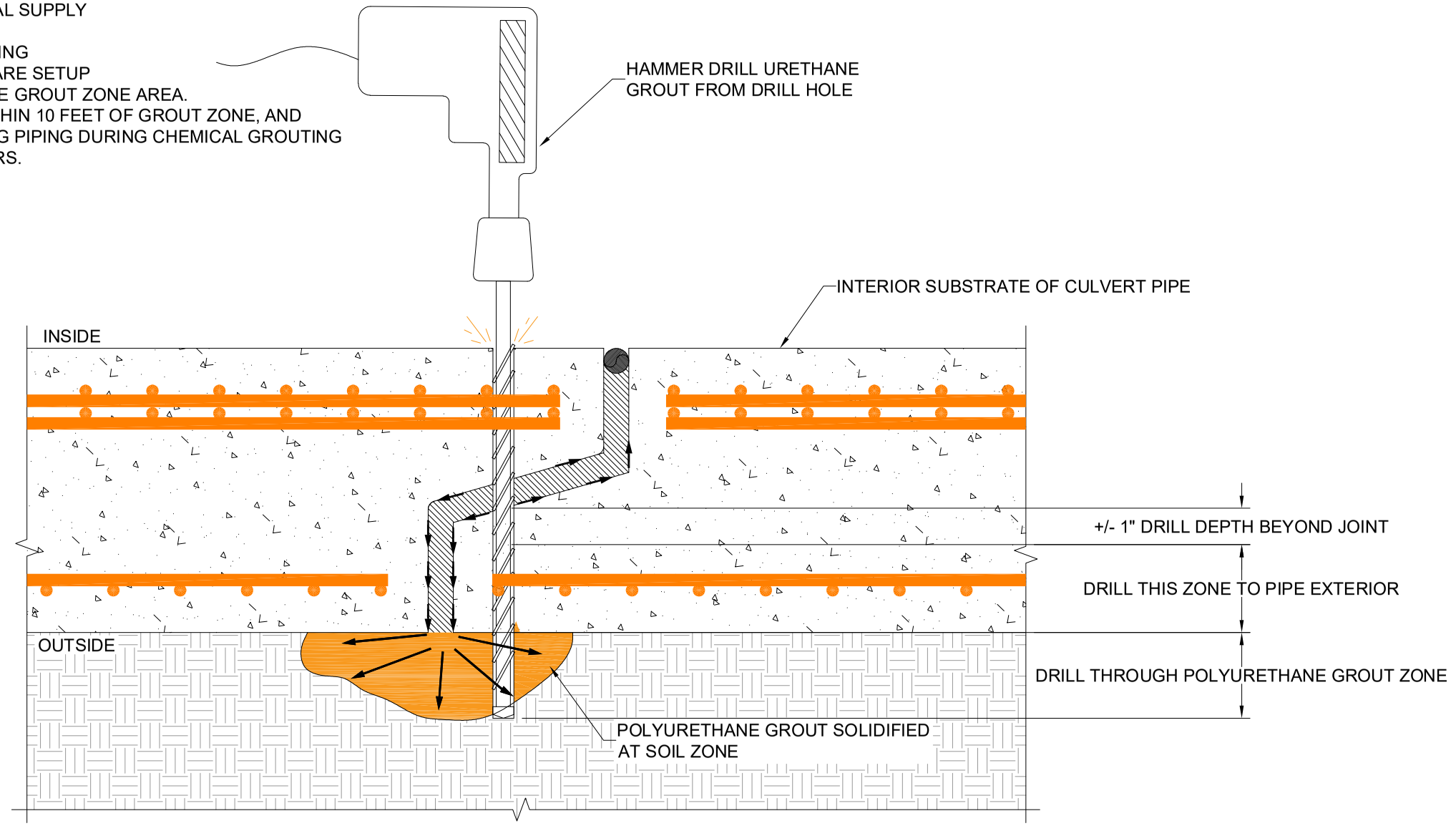
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 17A

1. COORDINATE SAFETY PLAN TO INCLUDE MANAGEMENT OF PACKER/PORT/MANCHETTE TOPS TO AVOID TRIP HAZARDS TO TRADESMEN
2. COORDINATE ACCESS/EGRESS PLAN IN CASE OF HIGH WATER, EXCESS CARBON DIOXIDE, LACK OF LIGHTING AND/OR OTHER ISSUES THAT MAY REQUIRE UNPLANNED EVACUATION OF CULVERT PIPE
3. COORDINATE WORKING TIMES TO ENSURE STORM WATER DRAINAGE DOES NOT INTERFERE WITH GROUTING OPERATIONS BEYOND MANAGED WATER RE-ROUTING
4. ENSURE PROJECT TEAM IS COORDINATED WITH WEATHER FORECASTS AND CURRENT CONDITIONS
5. ENSURE WATER DIVERSION PLAN IS APPROVED BY OWNER
6. FOLLOW ALL OSHA REQUIREMENTS FOR CONFINED SPACE
7. ENSURE:
   - 7.1. PROPER & ADEQUATE LIGHTING & ELECTRICAL SUPPLY
   - 7.2. PROPER & ADEQUATE FRESH AIR-SUPPLY
   - 7.3. PROPER & ADEQUATE AIR QUALITY MONITORING
   - 7.4. PROPER & ADEQUATE EYE WASH STATIONS ARE SETUP
8. IDENTIFY ALL BURIED UTILITIES WITHIN IMMEDIATE GROUT ZONE AREA.
9. IDENTIFY STORM OR SANITARY SEWER PIPES WITHIN 10 FEET OF GROUT ZONE, AND ESTABLISH SOME CRITERIA TO MONITOR EXISTING PIPING DURING CHEMICAL GROUTING TO ENSURE NO STRAY GROUT MIGRATION OCCURS.

1. REMOVE BALL VALVE INJECTION PORT / PACKER FROM INJECTION HOLE AND CLEAN FOR REUSE.
2. HAMMER OR CORE DRILL SAME INJECTION HOLE THRU CONCRETE PIPE FLANGE.

NOTE THE FOLLOWING:
- A. THE PIPE CIRCUMFERENCE IS 23 LINEAL FEET
- B. DRILL HOLES AT +/- 16" O.C. EQUATES TO 17 HOLES PER PIPE JOINT



1 ACRYLAMIDE GROUT, JOINT INJECTION
RE-DRILLING POLYURETHANE GROUT HOLES

Scale 1-1/2"=1'-0"

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TYPICAL PIPE JOINT CONDITIONS	5-9		
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"B" SERIES DRAWINGS	1B-30B	Section 03 64 20 Acrylamide Grout Joint Injection, Soil Solidification	WP-2
"C" SERIES DRAWINGS	1C-13C	Section 03 61 10 Ultra-Fine Cement, Soil Stabilization	SS-3
"D" SERIES DRAWINGS	1D-6D	Section 07 16 16 Crystalline Waterproofing	WP-4
"E" SERIES DRAWINGS	1E-22E	Section 03 64 10 Polyacrylate Grout Crack Injection	WP-5
"F" SERIES DRAWINGS	1F-6F	Section 03 64 23 Epoxy Resin Crack Injection	WP-6
"G" SERIES DRAWINGS	1G-4G	Section 07 13 56 Thermoplastic Sheet Strip Seals	WP-7

GENERAL NOTES:
1. STEEL REINFORCING VARIES AT LOCATIONS IN CULVERT PIPE.

NO.	DATE	REVISION	BY
1	1/9/2020	REVISIONS	TB

DES	DRN	CHK	JOB NO.
BA	TB	BA	
1/9/2020	1/9/2020	1/9/2020	

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RAYMOND ROAD CULVERT PIPE RESTORATION

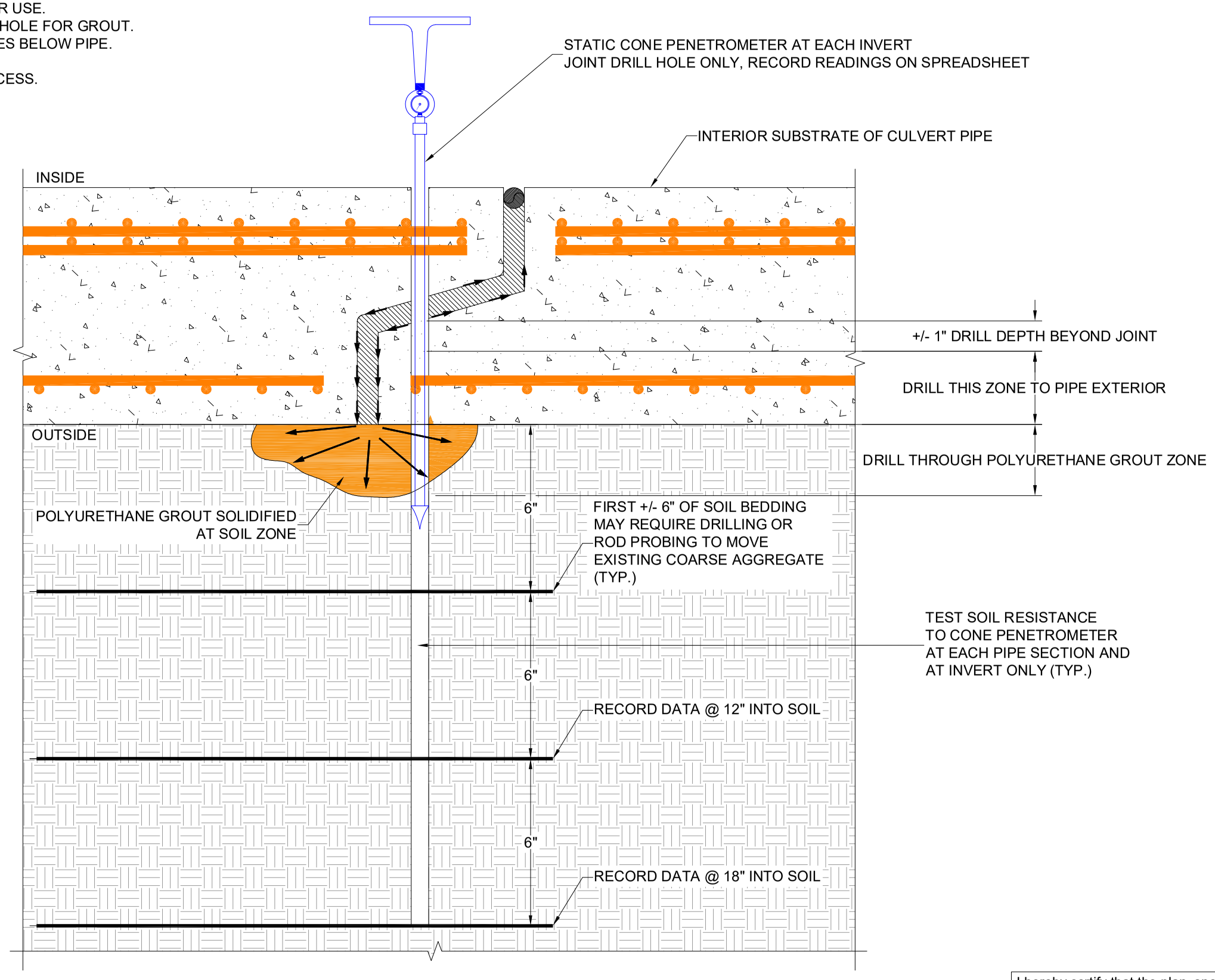
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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

SHEET: 1B

1. CALIBRATE STATIC CONE PENETROMETER.
2. FOLLOW MANUFACTURER'S INSTRUCTIONS FOR USE.
3. INSERT PENETROMETER INTO EXISTING DRILL HOLE FOR GROUT.
4. RECORD SOIL RESISTANCE AT 12 AND 18 INCHES BELOW PIPE.
5. EXTRACT PENETROMETER.
6. CONTINUE WITH ACRYLAMIDE GROUTING PROCESS.



2 ACRYLAMIDE GROUT, JOINT INJECTION
RE-DRILLING POLYURETHANE GROUT HOLES

Scale 1-1/2"=1'-0"

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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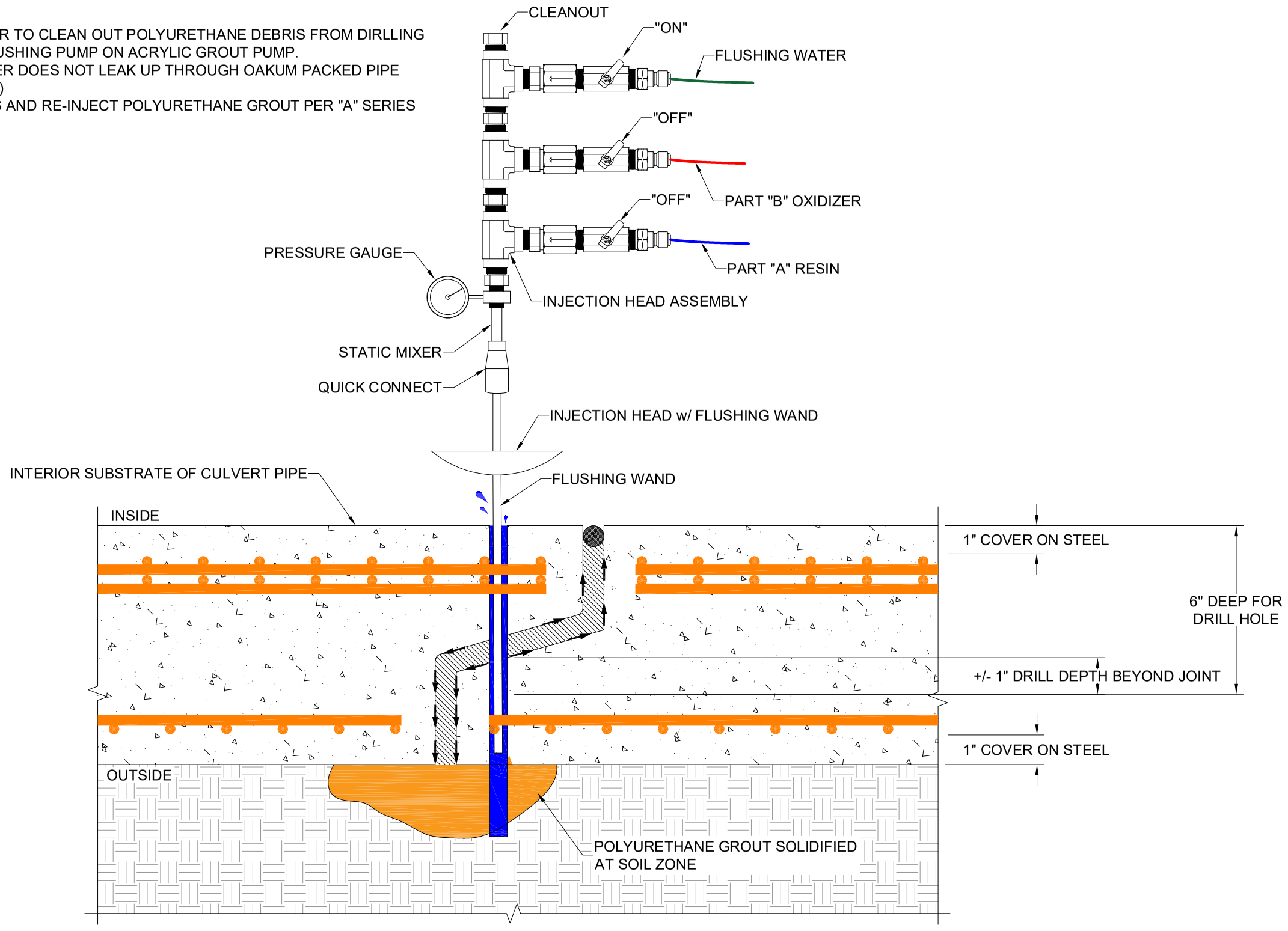
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 2B

1. FLUSH DRILL WITH PRESSURIZED WATER TO CLEAN OUT POLYURETHANE DEBRIS FROM DIRLLING
2. USE SEPARATE FLUSHING PUMP OR FLUSHING PUMP ON ACRYLIC GROUT PUMP.
3. ENSURE PRESSURIZED FLUSHING WATER DOES NOT LEAK UP THROUGH OAKUM PACKED PIPE FLANGE JOINT. (THIS IS A QA/QC CHECK)
4. IF LEAKAGE OCCURS, MARK LOCATIONS AND RE-INJECT POLYURETHANE GROUT PER "A" SERIES DRAWINGS.



3 ACRYLAMIDE GROUT, JOINT INJECTION
FLUSHING POLYURETHANE GROUT HOLES, LEAKAGE TESTING

Scale 1-1/2"=1'-0"

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RAYMOND ROAD CULVERT PIPE RESTORATION

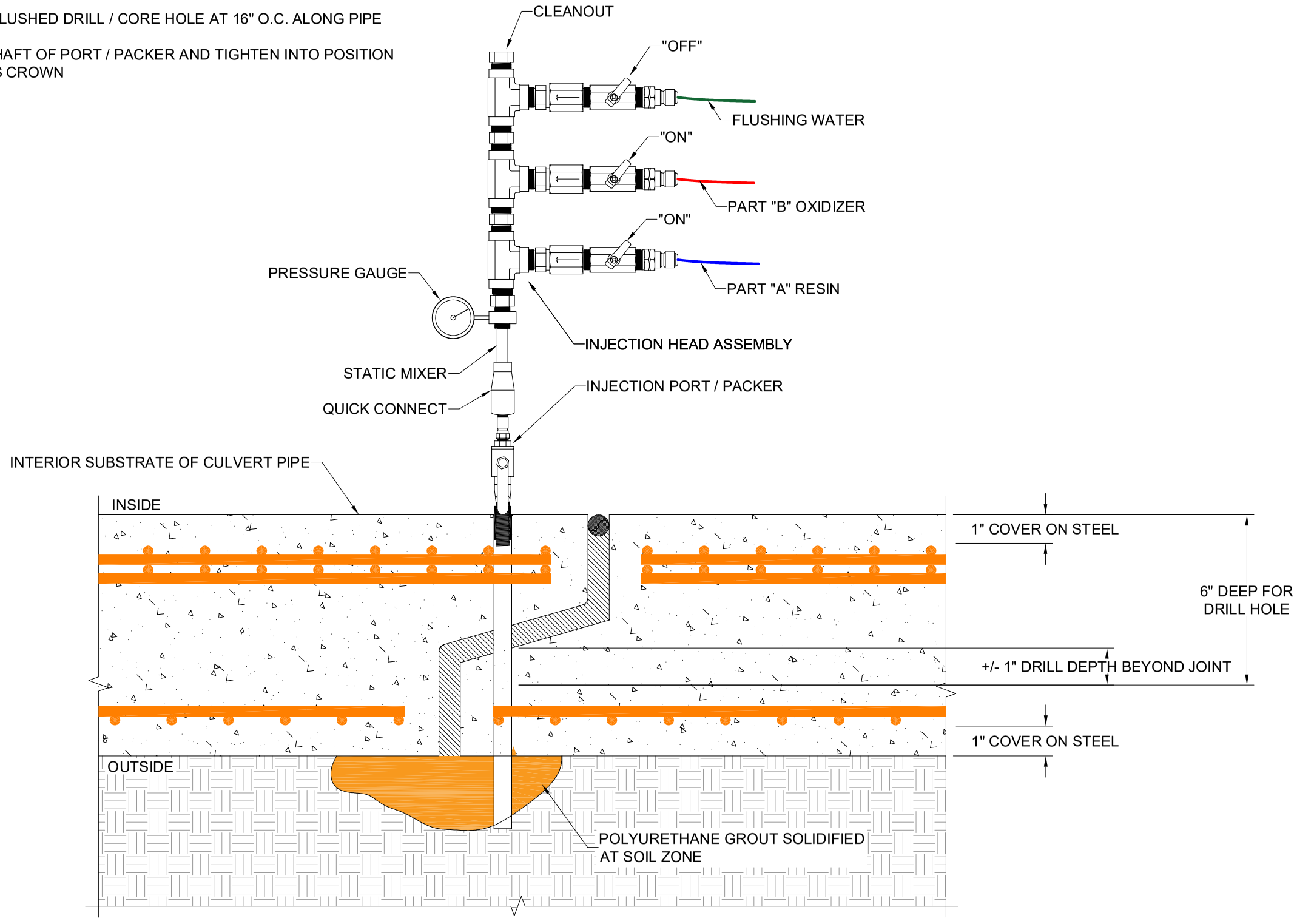
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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

SHEET: 3B

1. INSERT INJECTION PORT INTO WATER FLUSHED DRILL / CORE HOLE AT 16" O.C. ALONG PIPE CIRCUMFERENCE
2. USE PLASTIC COUPLER ON TAPERED SHAFT OF PORT / PACKER AND TIGHTEN INTO POSITION
3. START AT INVERT AND WORK TOWARDS CROWN



4 ACRYLAMIDE GROUT, JOINT INJECTION

PLACEMENT OF INJECTION PORT / PACKER

Scale 1-1/2"=1'-0"

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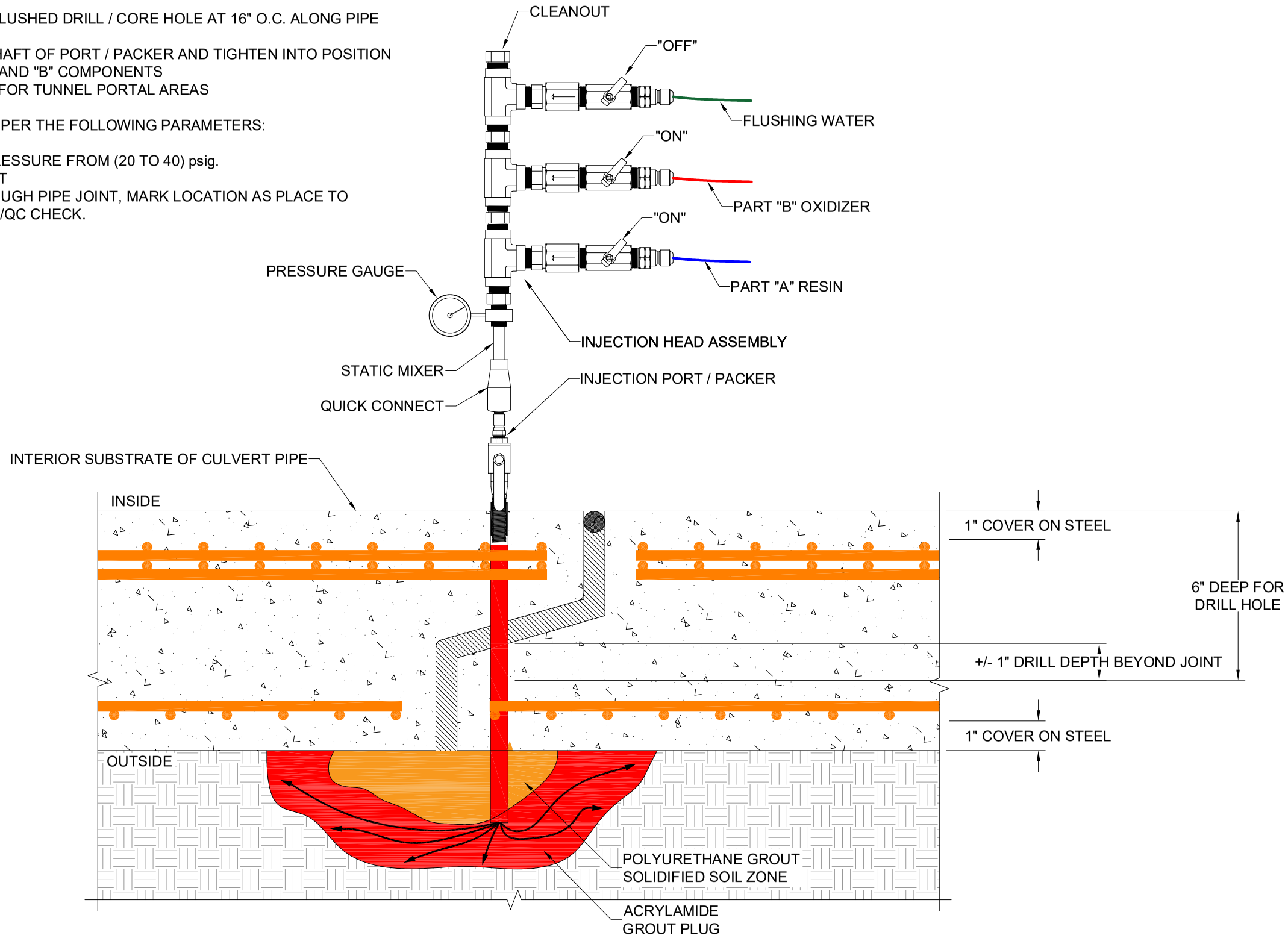
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 4B

1. INSERT INJECTION PORT INTO WATER FLUSHED DRILL / CORE HOLE AT 16" O.C. ALONG PIPE CIRCUMFERENCE
2. USE PLASTIC COUPLER ON TAPERED SHAFT OF PORT / PACKER AND TIGHTEN INTO POSITION
3. MIX UP ACRYLAMIDE GROUT PARTS "A" AND "B" COMPONENTS
4. NOTE SPECIAL GROUT FORMULATIONS FOR TUNNEL PORTAL AREAS
5. SET UP CHEMICAL GROUT EQUIPMENT
6. START INJECTING ACRYLAMIDE GROUT PER THE FOLLOWING PARAMETERS:
   - 6.1. USE 40% LIQUID AV-100 ON "A" SIDE
   - 6.2. PUMP ACRYLAMIDE GROUT AT A PRESSURE FROM (20 TO 40) psig.
   - 6.3. PUMP 3 GALLONS PER 16" O.C. PORT
7. IF ACRYLAMIDE GROUT LEAKS UP THROUGH PIPE JOINT, MARK LOCATION AS PLACE TO RE-INJECT POLYURETHANE GROUT. QA/QC CHECK.



5 ACRYLAMIDE GROUT, JOINT INJECTION

ACRYLAMIDE INJECTION, QA/QC CHECK

Scale 1-1/2"=1'-0"

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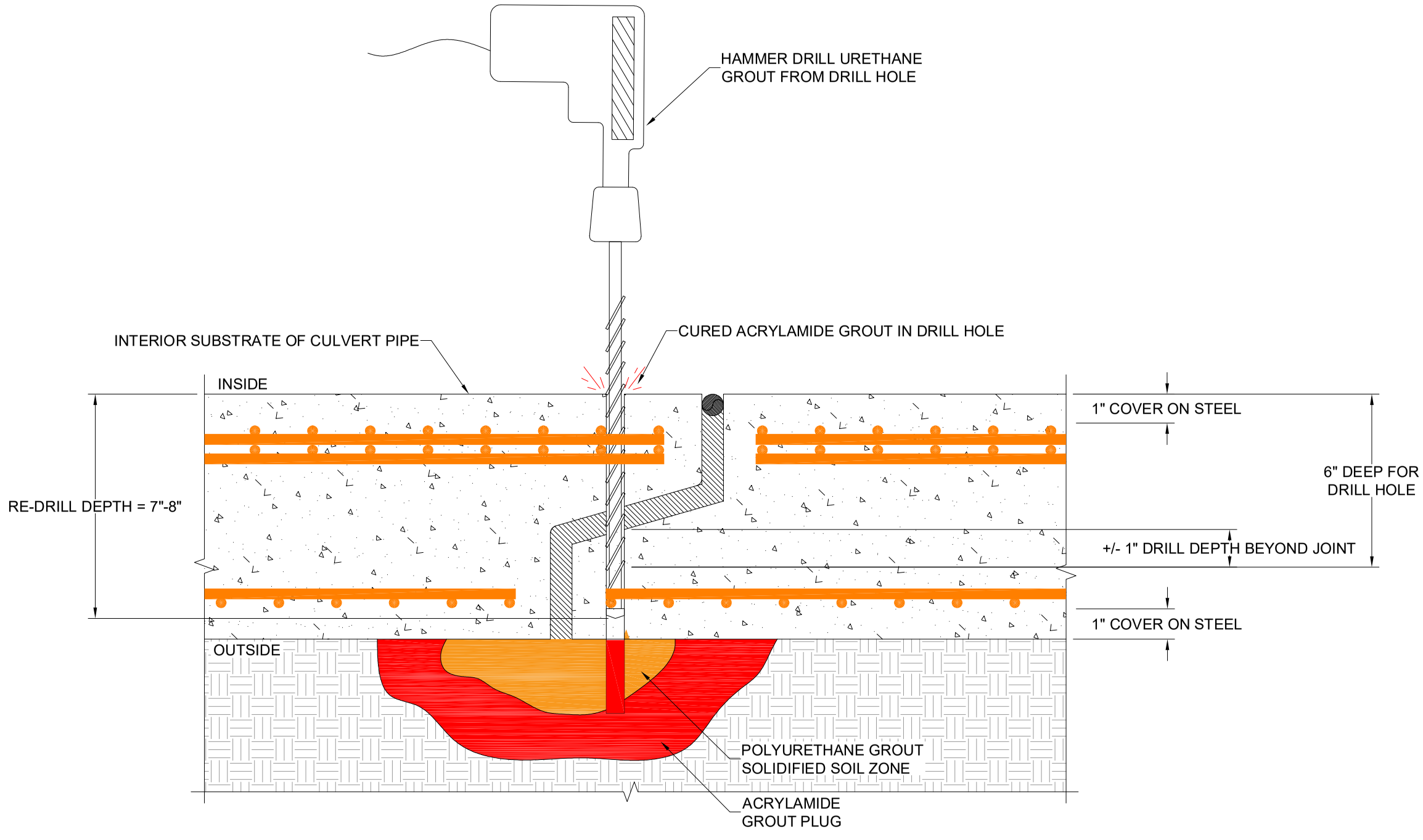
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 5B

1. AFTER 1 HOUR, ACRYLAMIDE GROUT SHOULD BE CURED ENOUGH TO RE-DRILL INJECTION HOLES.
2. ENSURE DRILLING DEPTH IS ROUGHLY 7 TO 8 INCHES.



6 ACRYLAMIDE GROUT, JOINT INJECTION

RE-DRILLING ACRYLAMIDE GROUT HOLES

Scale 1-1/2"=1'-0"

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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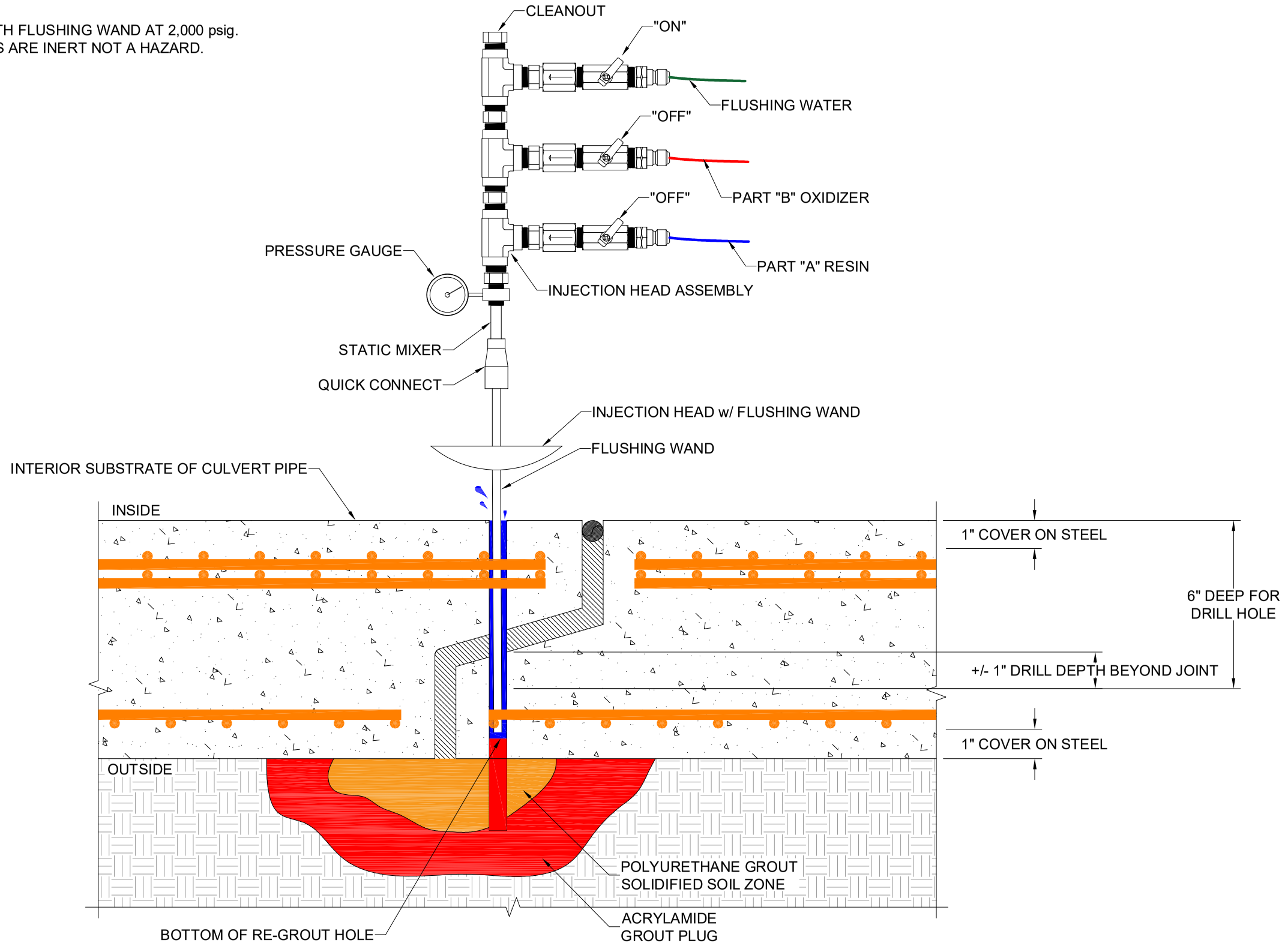
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 6B

1. FLUSH DRILL HOLES AT EACH JOINT WITH FLUSHING WAND AT 2,000 psig.
2. CURED ACRYLAMIDE GROUT PARTICLES ARE INERT NOT A HAZARD.



7 ACRYLAMIDE GROUT, JOINT INJECTION
DRILL HOLE FLUSHING

Scale 1-1/2"=1'-0"

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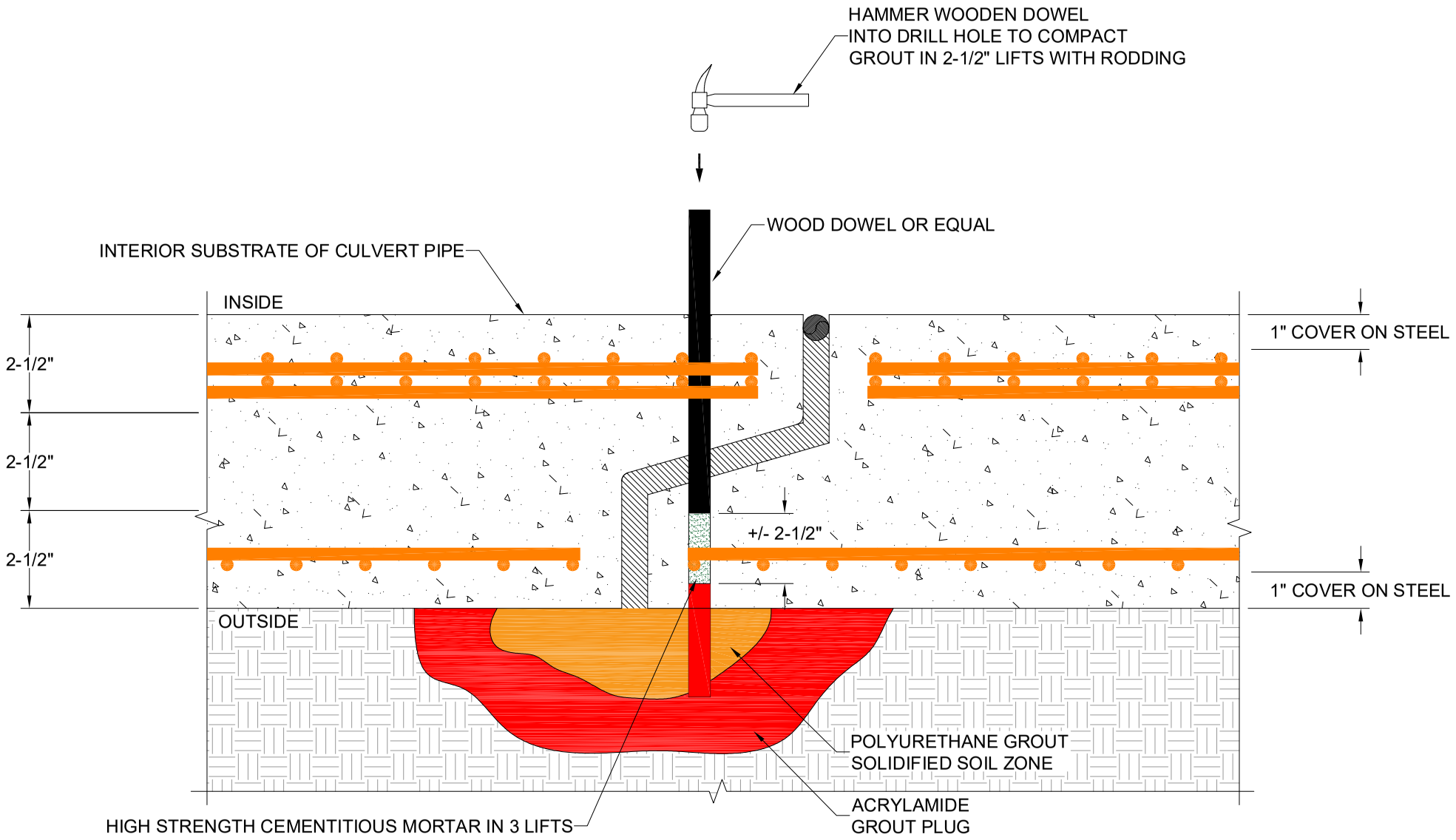
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 7B

1. SELECT A HIGH STRENGTH CEMENTITIOUS CONCRETE MORTAR MIX.
2. MIX REPAIR MORTAR PER MANUFACTURERS INSTRUCTIONS
3. PLACE MORTAR IN DRILL HOLE AND COMPACT WITH WOOD DOWEL IN 3 LIFTS, APPROXIMATELY 2-1/2" PER LIFT.
4. FLUSH MORTAR AT PIPE SURFACE.



8 ACRYLAMIDE GROUT, JOINT INJECTION
1st LIFT OF HIGH STRENGTH MORTAR

Scale 1-1/2"=1'-0"

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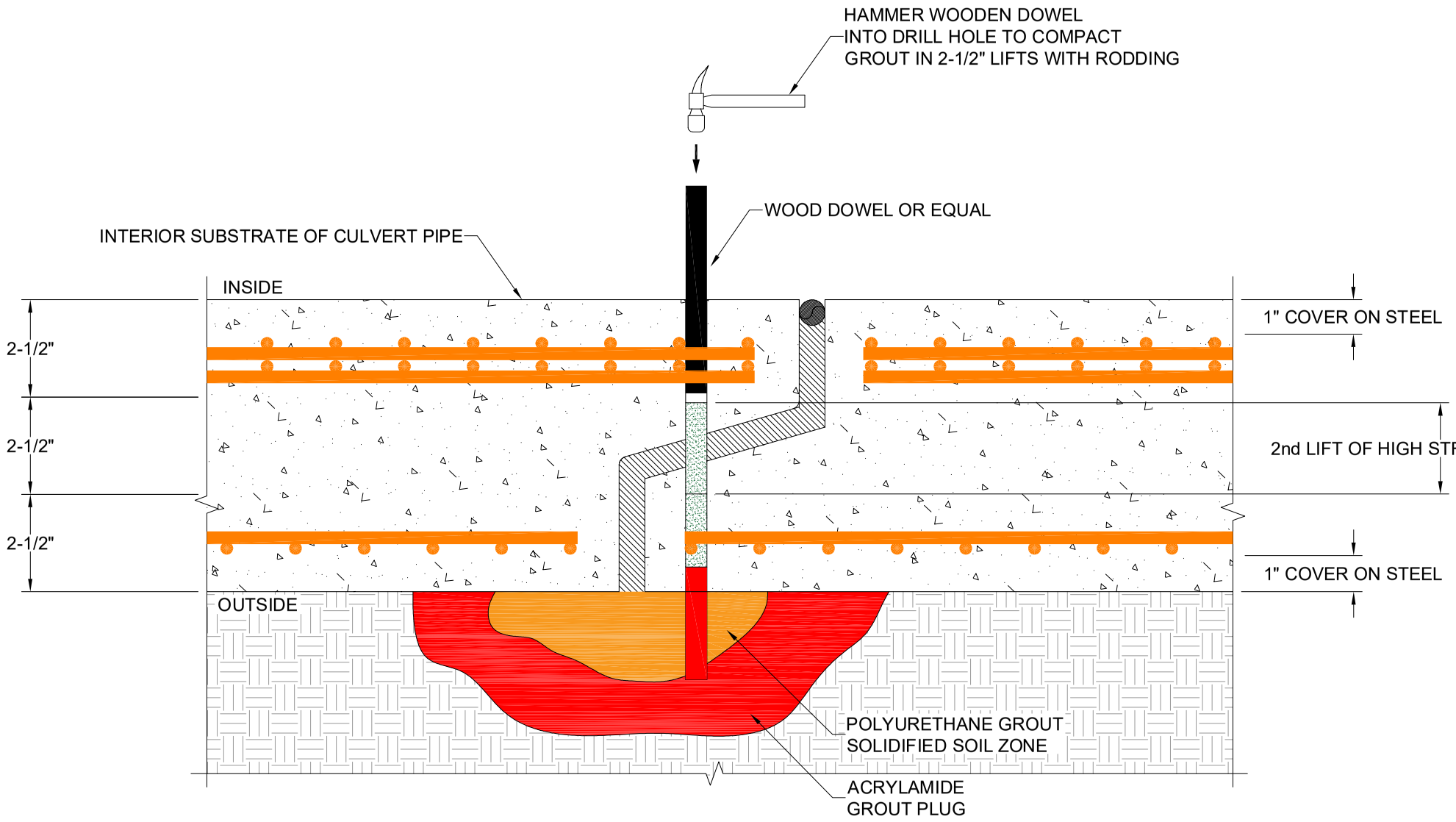
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 8B

1. REPEAT PROCESS OF FILLING DRILL HOLE AND RODDING (COMPACTION).



9 ACRYLAMIDE GROUT, JOINT INJECTION
2nd LIFT OF HIGH STRENGTH MORTAR

Scale 1-1/2"=1'-0"

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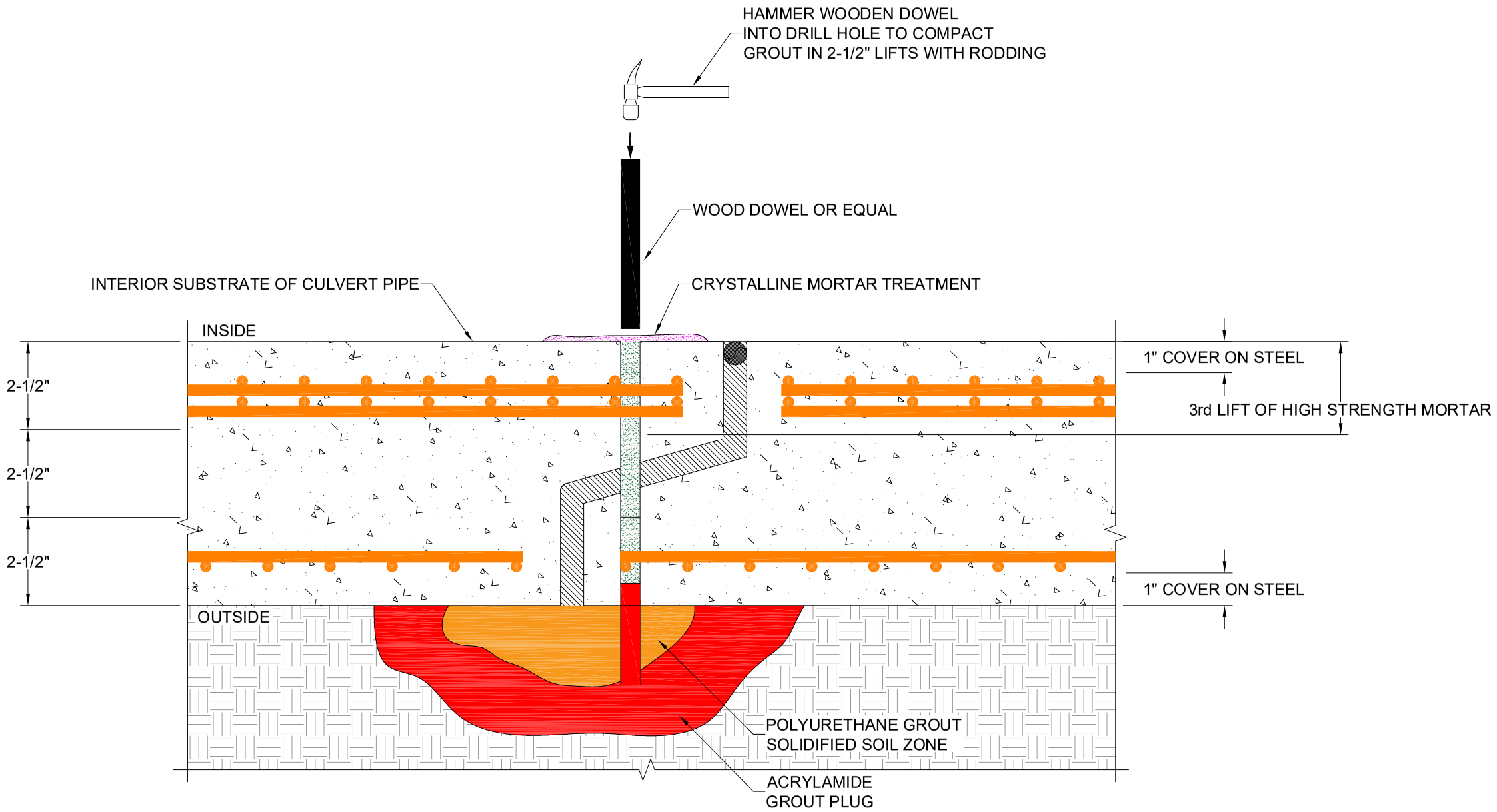
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 9B

1. UPON COMPLETION OF 3rd LIFT WITH HIGH STRENGTH MORTAR, INSTALL A +/- (4" X 4") SLURRY COAT OVER PATCH OF CRYSTALLINE WATERPROOFING (WP-4)



10 ACRYLAMIDE GROUT, JOINT INJECTION
3rd LIFT OF HIGH STRENGTH MORTAR FILL

Scale 1-1/2"=1'-0"

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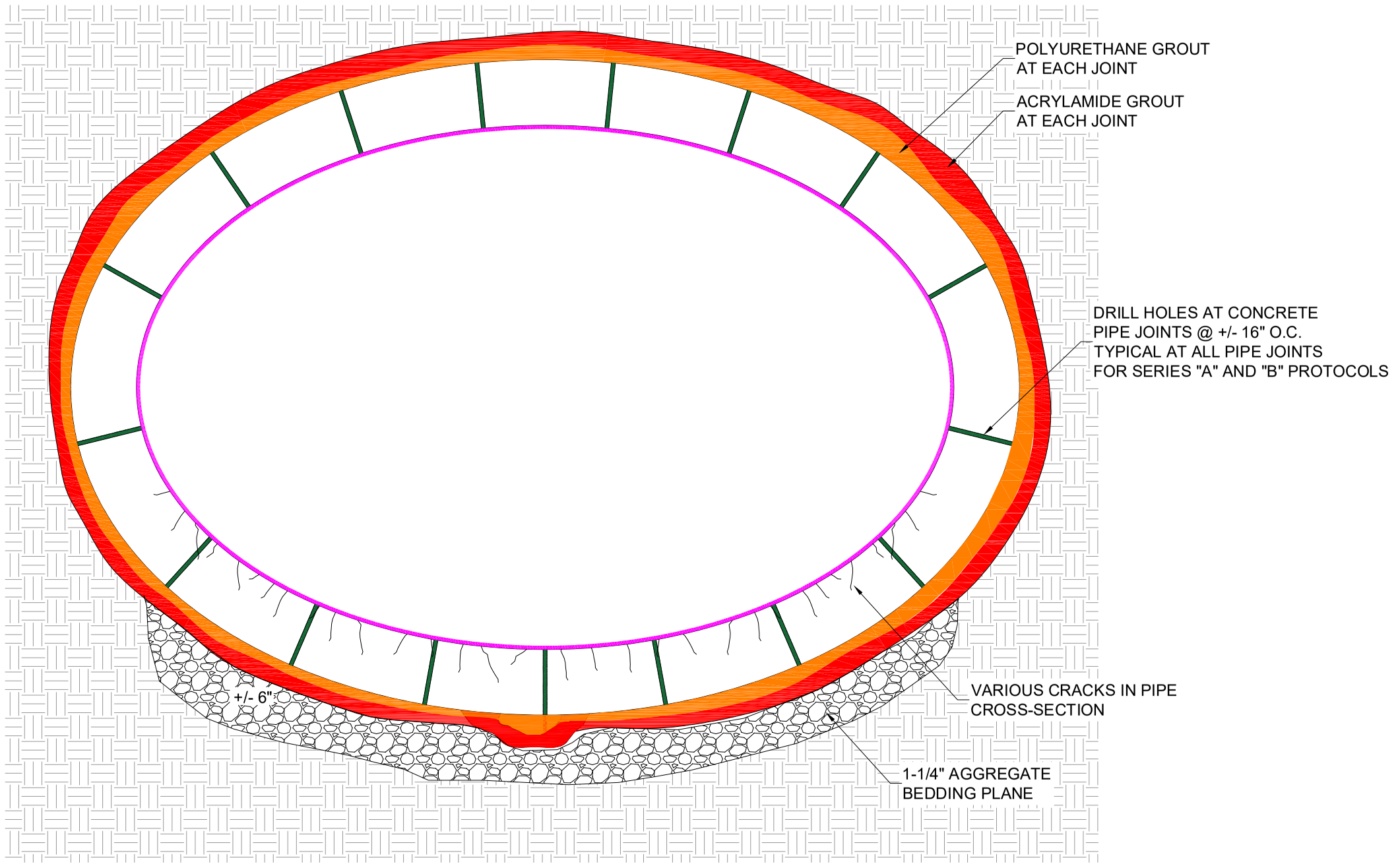
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 10B



11 DRILL HOLE LAYOUT AT +/- 16" O.C. AT CONCRETE PIPE JOINTS

ACRYLAMIDE GROUT PLUG AROUND PERIMETER OF PIPE JOINTS

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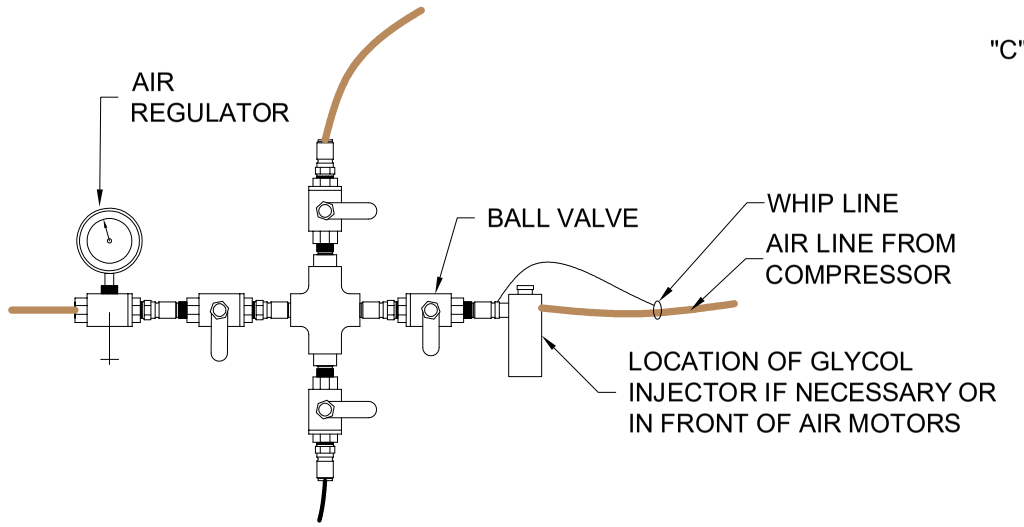
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RAYMOND ROAD CULVERT PIPE RESTORATION

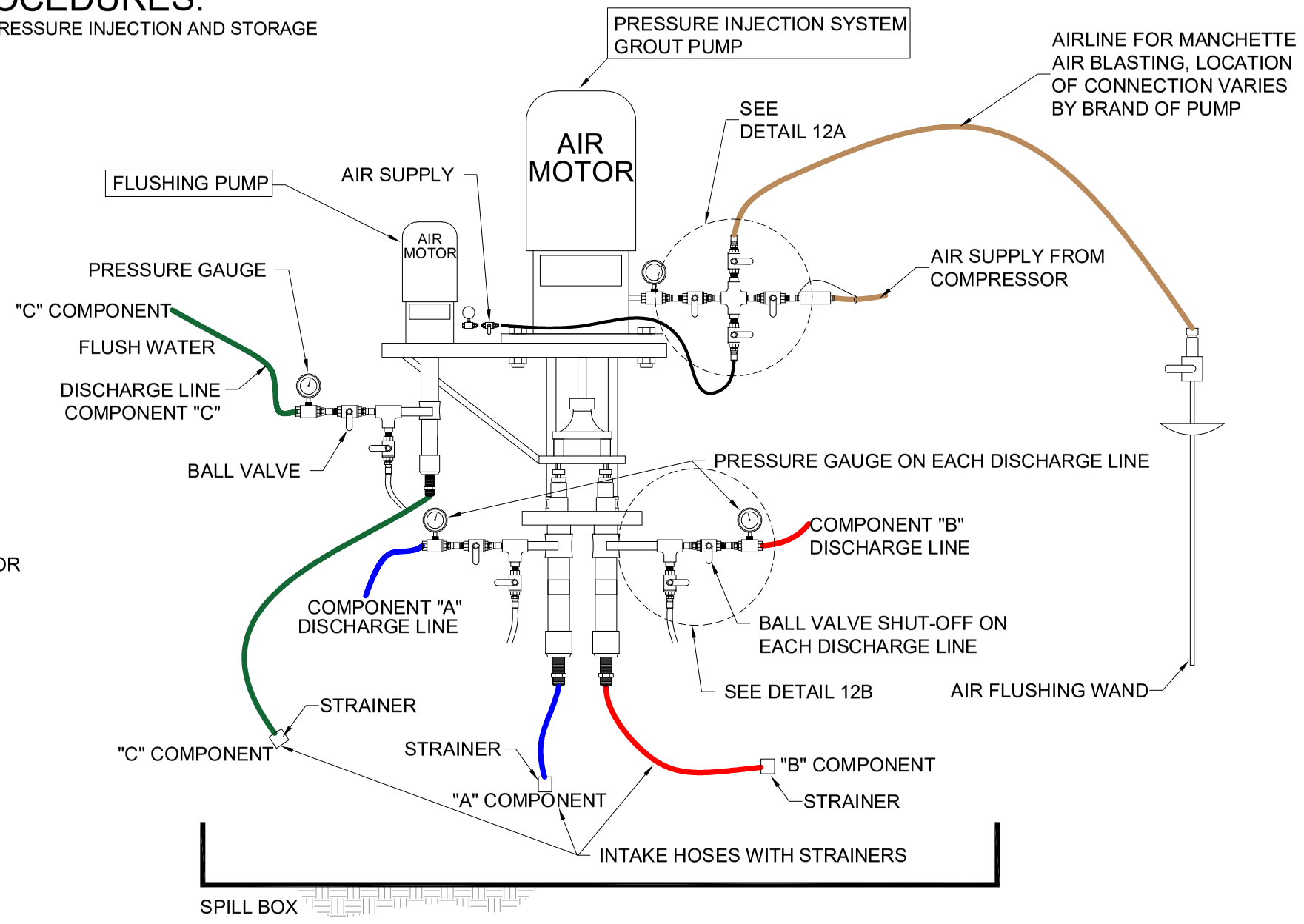
SHEET: 11B

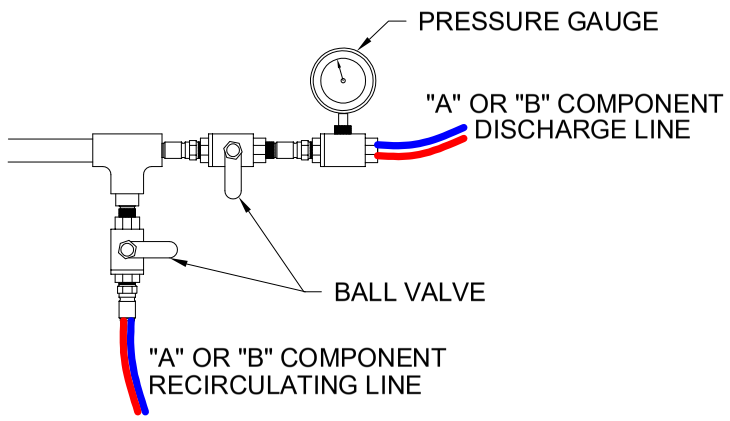
ACRYLAMIDE GROUT EQUIPMENT AND PROCEDURES:

EQUIPMENT SETUP FOR CHEMICAL GROUT SYSTEM (CGS) - CLEANING, FLUSHING, PRESSURE INJECTION AND STORAGE



12A AIR LINE SET-UP





12B DETAIL OF DISCHARGE AND RE-CIRCULATING LINES

12 ACRYLAMIDE GROUT, JOINT INJECTION

GROUT & FLUSHING PUMP SET-UP & COMPONENTS
GROUT PUMP NOT SHOWN FOR CLARITY

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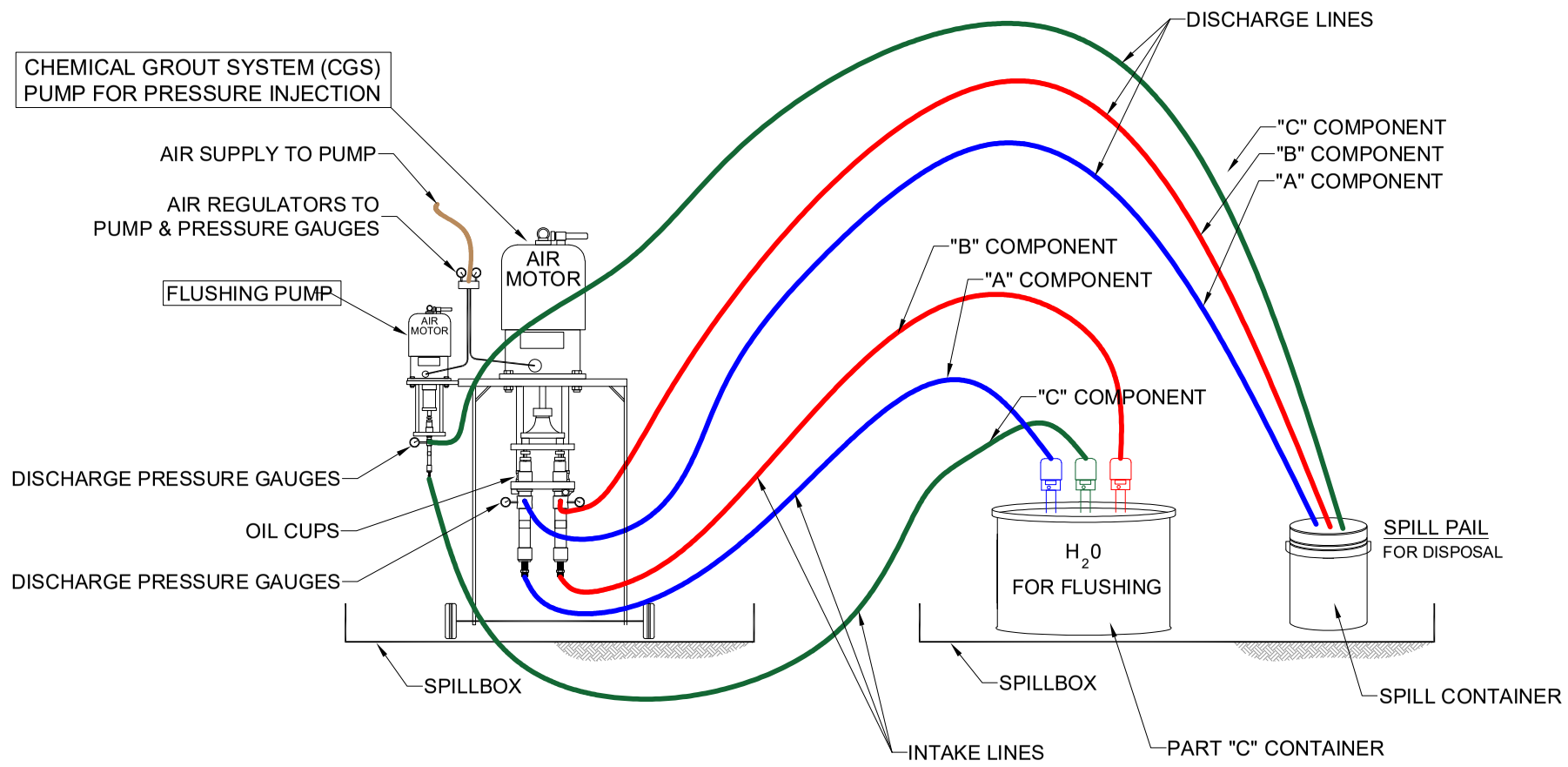
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 12B

1. SET PUMP ON / WITHIN SPILL BOX WITH TEAR RESISTANT MEMBRANE, RAISED ON SIDES
2. ATTACH AIR COMPRESSOR HOSE TO AIR LINE INTAKE ON PRESSURE INJECTION PUMP WITH APPROVED FITTING AND ANTI-WHIP LINE
3. INSTALL ETHYLENE GLYCOL IN LUBRICATOR IF COLD TEMPERATURES ARE PRESENT OR CONSTANT PUMPING IS REQUIRED
4. FILL PART "C" CONTAINER WITH CLEAN WATER
5. PLACE INTAKE LINE FROM FLUSHING PUMP "C" COMPONENT AND BOTH "A" & "B" COMPONENT PRESSURE INJECTION PUMP INTAKE LINES OF CHEMICAL GROUT SYSTEM (CGS) INTO PART "C" CONTAINER
6. PLACE ALL THREE DISCHARGE LINES IN SPILL PAIL ("A" + "B" + "C")
7. TURN CHEMICAL GROUT SYSTEM (CGS) PUMP ON AT LOW SPEED AND PRESSURE, ENSURE ALL THREE LINES DISCHARGE LIQUIDS INTO SPILL PAIL
8. CIRCULATE WATER THROUGH SYSTEM UNTIL ALL OIL FROM STORAGE IS FLUSHED OUT
9. CHECK TO ENSURE RATIO OF "A" & "B" COMPONENTS IS EQUAL OR WITHIN 10% OF EACH OTHER, SEE SHEET 23B

* NOTE:
- RE-CIRCULATING DISCHARGE LINES NOT SHOWN FOR CLARITY
- PUMP IS USUALLY STORED WITH VEGETABLE OIL IN SYSTEM.
- THIS IS NON-HAZARDOUS AND CAN EASILY BE DISPOSED.



13 ACRYLAMIDE GROUT, JOINT INJECTION

GROUT PUMP FLUSHING OF STORAGE OIL FROM SYSTEM
GROUT PUMP PREPERATION

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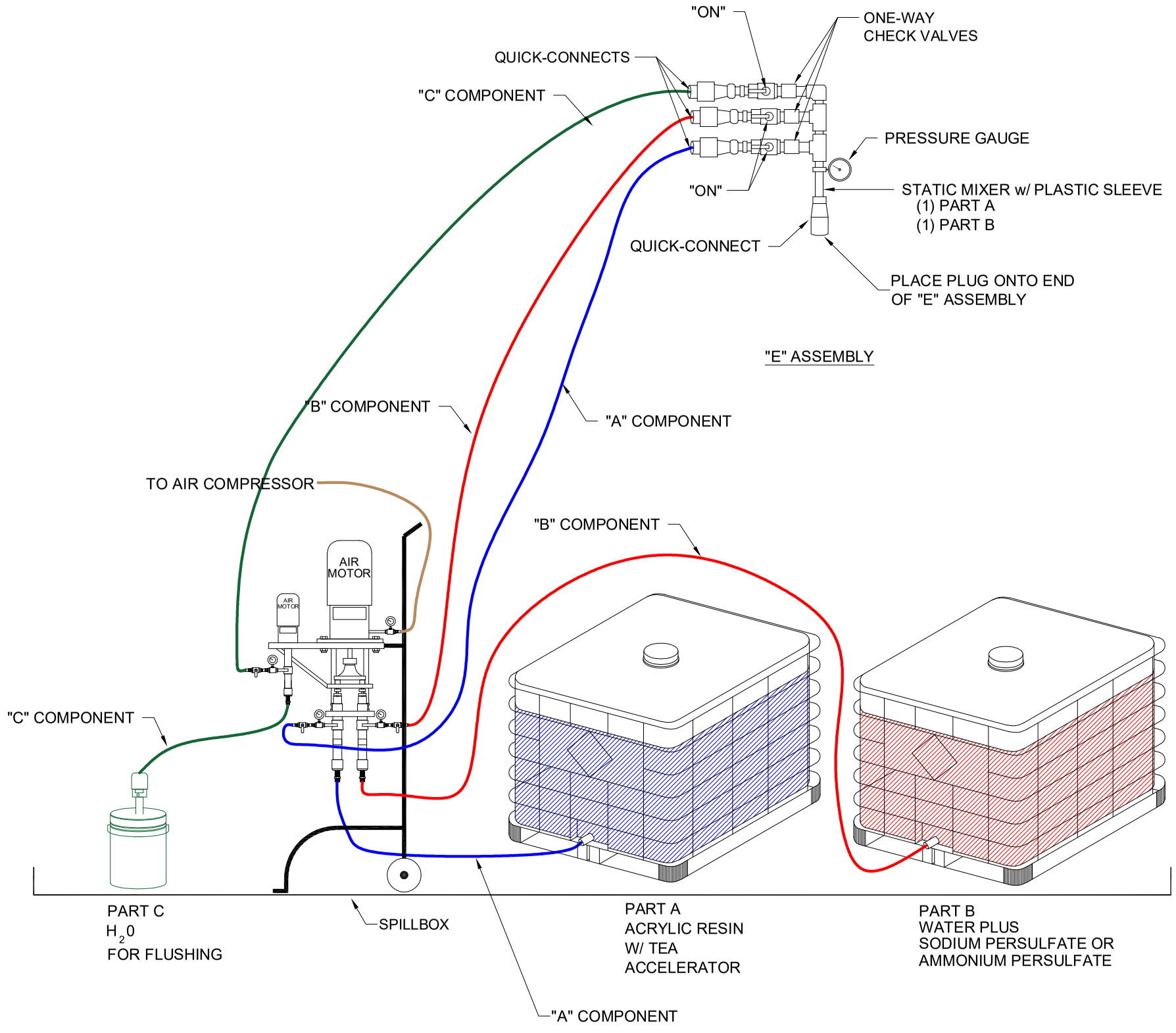
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 13B

1. PUT "PLUG" ONTO END OF "E" ASSEMBLY INJECTION GUN AND TURN PRESSURE UP TO 500 psig, ENSURE ALL FITTINGS ARE LEAK-FREE
2. MAKE ADJUSTMENTS WHERE NECESSARY IF LEAKAGE AT MECHANICAL CONNECTIONS OCCUR



14 ACRYLAMIDE GROUT, JOINT INJECTION

GROUT PUMP PRESSURE TESTING

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

NO.	DATE	REVISION	BY
1	1/9/2020	REVISIONS	TB

DES BA 1/9/2020
DRN TB 1/9/2020
CHK BA 1/9/2020
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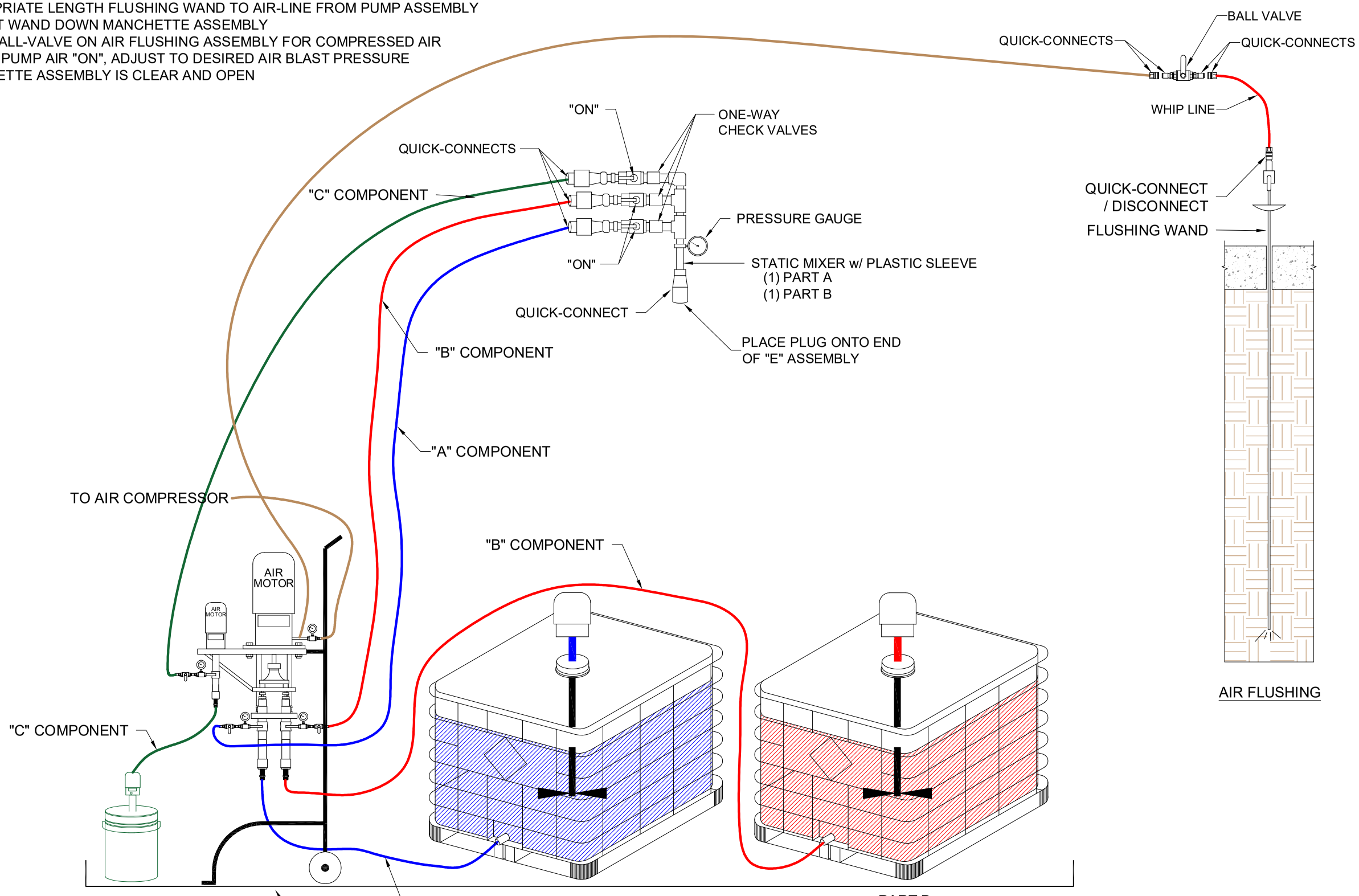
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 14B

AIR FLUSHING DRILL HOLES:

1. ATTACH APPROPRIATE LENGTH FLUSHING WAND TO AIR-LINE FROM PUMP ASSEMBLY
2. PLACE AIR BLAST WAND DOWN MANCHETTE ASSEMBLY
3. SLOWLY OPEN BALL-VALVE ON AIR FLUSHING ASSEMBLY FOR COMPRESSED AIR
4. TURN FLUSHING PUMP AIR "ON", ADJUST TO DESIRED AIR BLAST PRESSURE
5. ENSURE MANCHETTE ASSEMBLY IS CLEAR AND OPEN



AIR FLUSHING

15 ACRYLAMIDE GROUT, JOINT INJECTION

CLASSIC SET-UP FOR AIR FLUSHING MANCHETTES PRIOR TO GROUTING
NOTE: RE-CIRCULATING LINES NOT SHOWN FOR CLARITY

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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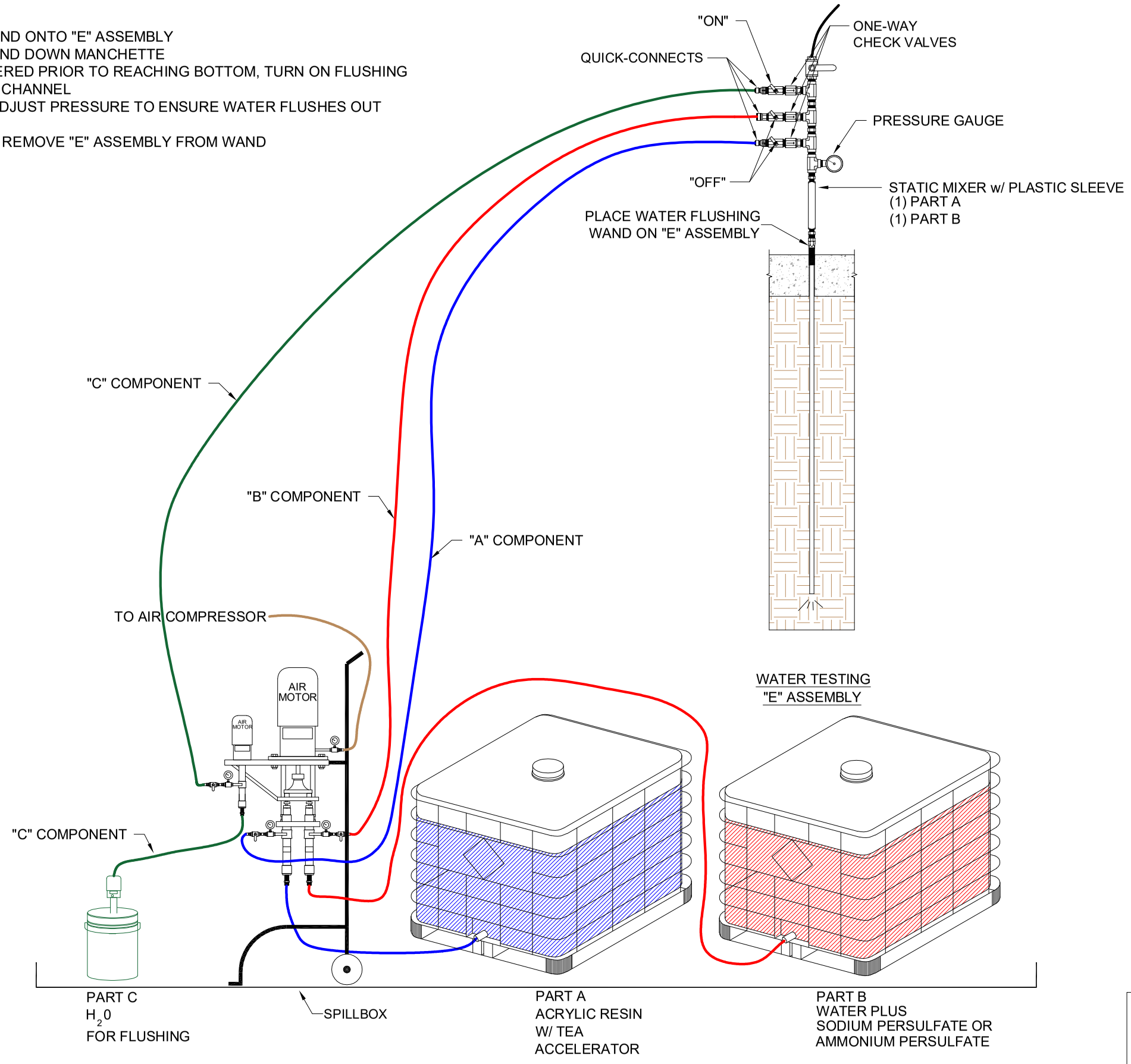
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 15B

WATER FLUSHING MANCHETTE:

1. PLACE WATER FLUSHING WAND ONTO "E" ASSEMBLY
2. PLACE WATER FLUSHING WAND DOWN MANCHETTE
3. IF RESISTANCE IS ENCOUNTERED PRIOR TO REACHING BOTTOM, TURN ON FLUSHING WATER PRESSURE TO OPEN CHANNEL
4. TURN FLUSHING PUMP ON, ADJUST PRESSURE TO ENSURE WATER FLUSHES OUT MANCHETTE ASSEMBLY
5. TURN FLUSHING PUMP OFF - REMOVE "E" ASSEMBLY FROM WAND



16 ACRYLAMIDE GROUT, JOINT INJECTION

CLASSIC SET-UP FOR WATER FLUSHING MANCHETTES PRIOR TO GROUTING
NOTE: RE-CIRCULATING LINES NOT SHOWN FOR CLARITY

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 16B

20% SOLUTION GROUT MADE WITH 40% CONCENTRATION OF LIQUID ACRYLAMIDE

"A" COMPONENT MIXING

1. POSITION 40% ACRYLAMIDE RESIN TOTE ON SPILL PAD (265 GALS)
2. OPEN LID ON TOTE
3. ADD 1 PAIL (50 LBS) OF TEA ACCELERATOR TO TOTE
4. ADD 1/4 to 1/3 CUP OF BLUE DYE TO TOTE
5. PLACE PADDLE IN "A" RESIN TOTE AND SLOWLY MIX FOR 5 MINUTES
6. MEASURE TEMPERATURE OF "A" COMPONENT RESIN
7. HEAT OR COOL IF NECESSARY
8. PLACE LID BACK ON TOTE UNTIL READY FOR USE

"B" COMPONENT MIXING

1. POSITION OXIDIZER TOTE AND FILL WITH 260 GALLONS OF CLEAN WATER
2. ADD 1 PAIL (50 LBS) OF WHITE POWDER (AMMONIUM PERSULFATE) TO WATER
3. ADD 1/4 to 1/3 CUP OF RED DYE TO OXIDIZER TOTE
4. PLACE PADDLE IN "B" RESIN TOTE AND SLOWLY MIX FOR 10 MINUTES
5. MEASURE TEMPERATURE OF "B" COMPONENT FLUID
6. HEAT OR COOL IF NECESSARY
7. PLACE LID BACK ON TOTE UNTIL READY FOR USE

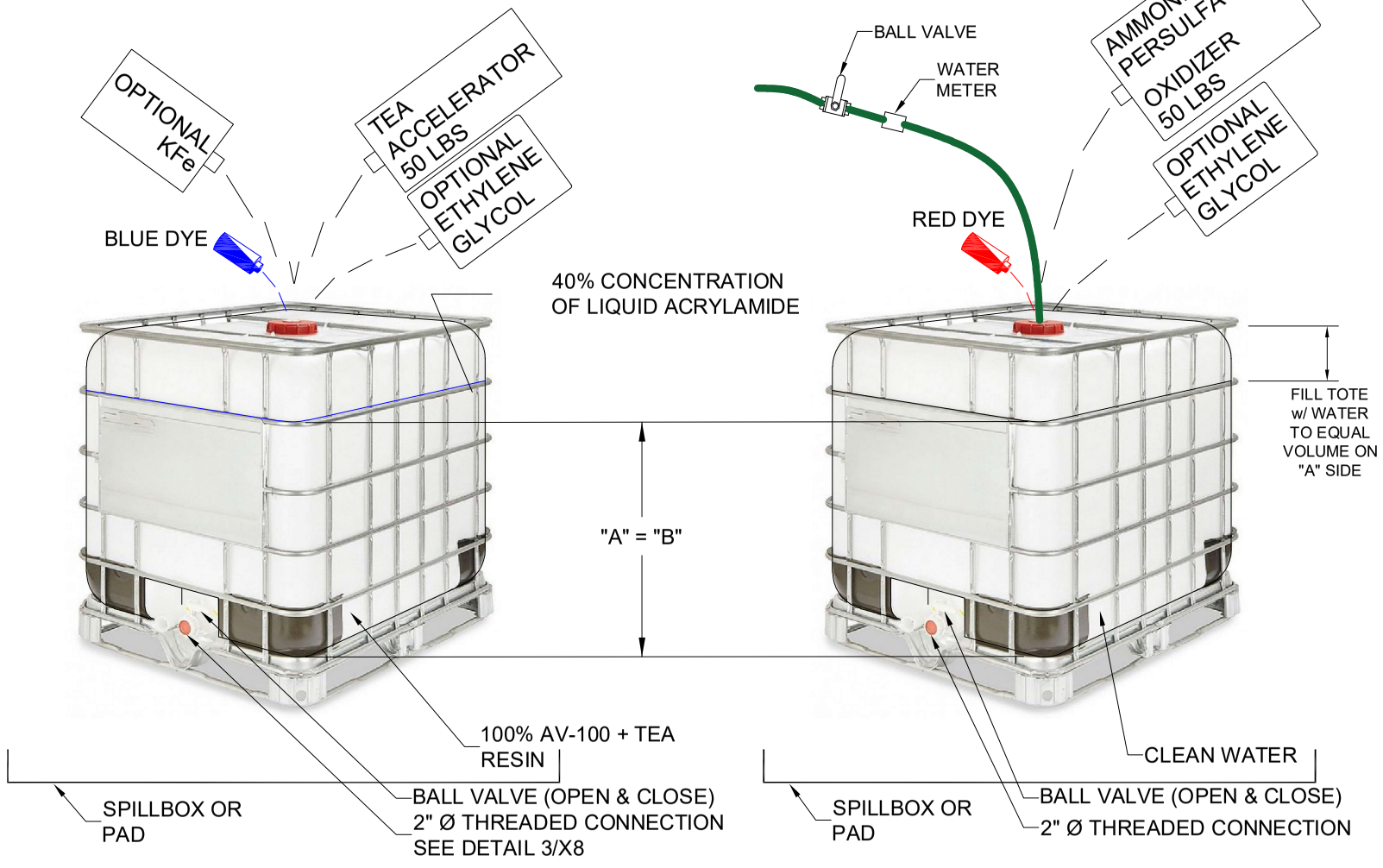
GENERAL NOTES:

A. AV-100 IS PURCHASED IN 40% CONCENTRATION OF ACRYLAMIDE IN WATER
B. ETHYLENE GLYCOL CAN BE ADDED TO EITHER OR BOTH "A" AND/OR "B" COMPONENT
C. KFe CAN BE ADDED TO "A" COMPONENT TO EXTEND GEL TIME

KFe RETARDER @ 70 ° F, MIX	
1-2 oz. / TOTE	10 MIN.
3-5 oz. / TOTE	20 MIN.
6-9 oz. / TOTE	30 MIN.
10-13 oz. / TOTE	40 MIN.
14-17 oz. / TOTE	50 MIN.
18-21 oz. / TOTE	60 MIN.
+/- 2 lbs. / TOTE	+/- 2 HRS

ADDITION OF ETHYLENE GLYCOL
GROUT STABILIZATION (FOR EXPANSION & SHRINKAGE CONTROL)

5 GAL EACH TOTE	LOW
10 GAL EACH TOTE	MEDIUM
15 GAL EACH TOTE	GOOD
20 GAL EACH TOTE	EXCELLENT



17A "A" COMPONENT MIXING

"A" RESIN TOTE
98% AV-100 RESIN + 2% TEA ACCELERATOR

17B "B" COMPONENT MIXING

"B" RESIN TOTE
98% WATER + 2% AMMONIUM PERSULFATE

17 ACRYLAMIDE GROUT, JOINT INJECTION

MIXING A & B COMPONENTS

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 17B

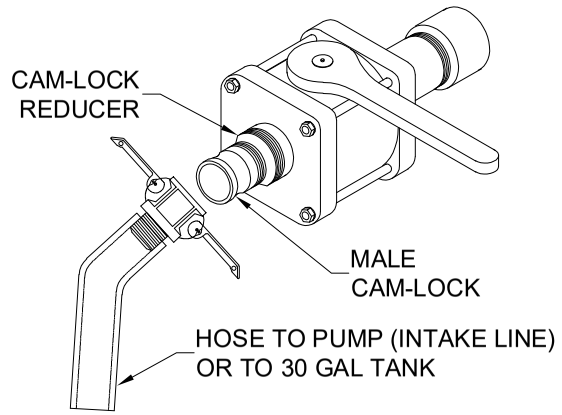
20% SOLUTION GROUT MADE WITH 40% CONCENTRATION OF LIQUID ACRYLAMIDE

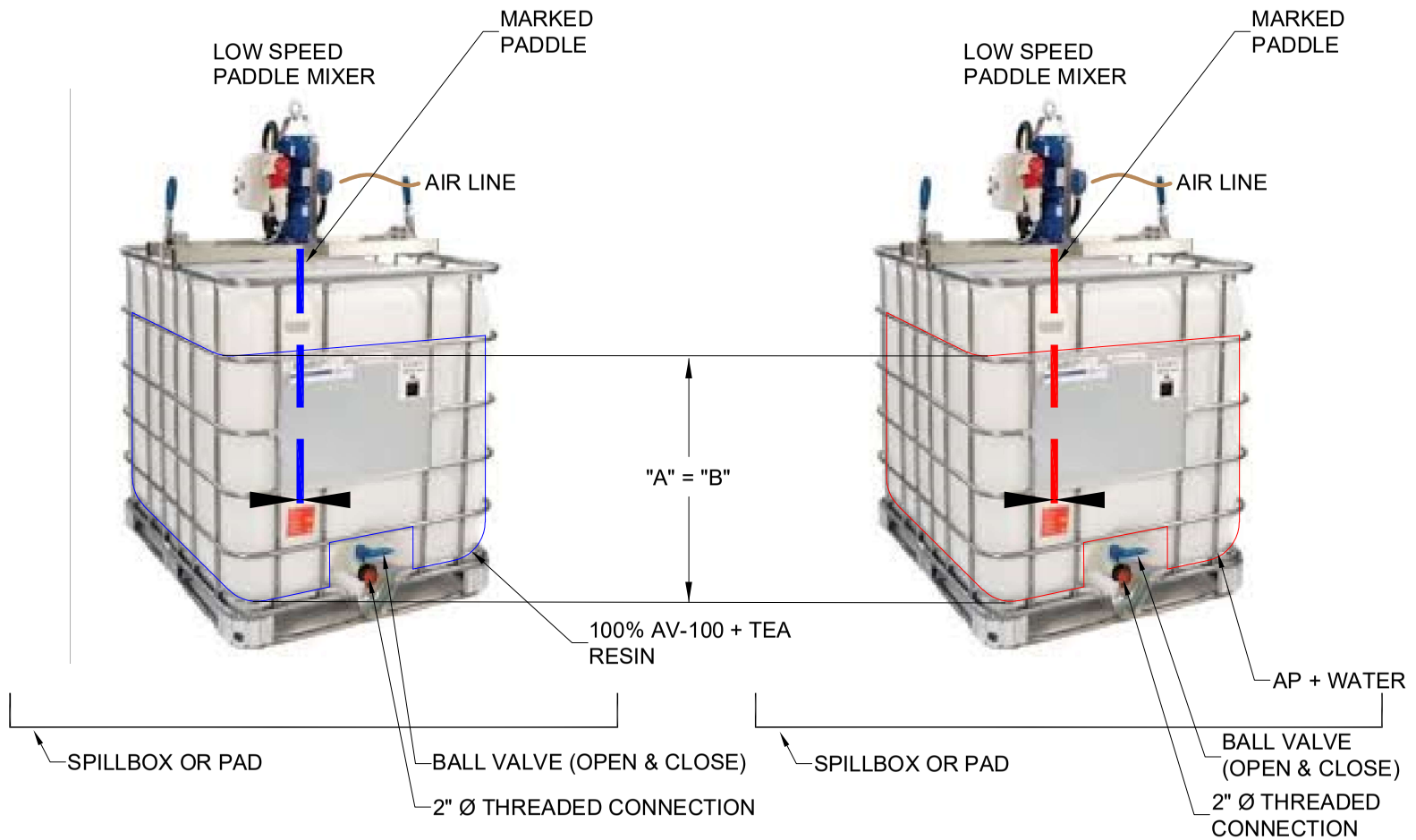
"A" COMPONENT MIXING

1. PLACE LID BACK ON TOTE UNTIL READY FOR USE
2. MARK "A" RESIN PADDLE WITH BLUE LABEL OR TAPE TO ENSURE AGAINST CROSS-CONTAMINATION IN "B" COMPONENT
3. HOOK UP LINE FROM COMPRESSOR TO AIR-OPERATED AGITATOR
4. AGITATE LIQUID AT LOW SPEED TO ENSURE BLENDED MIXTURE
5. HOOKUP 2" BALL VALVE w/ NPT TO TOTE DISCHARGE
6. HOOKUP GROUT PUMP INTAKE TO TOTES w/ THREADED HOSE CONNECTIONS

"B" COMPONENT MIXING

1. MARK "B" RESIN PADDLE WITH RED LABEL OR TAPE TO ENSURE AGAINST CROSS-CONTAMINATION IN "A" COMPONENTS
2. FILL TOTE TO AN EQUAL VOLUME AS ON "A" SIDE
3. HOOK UP LINE FROM COMPRESSOR TO AIR-OPERATED AGITATOR
4. AGITATE LIQUID AT LOW SPEED TO ENSURE BLENDED MIXTURE
5. HOOKUP 2" BALL VALVE W/ NPT TO TOTE DISCHARGE
6. HOOKUP GROUT PUMP INTAKE TO TOTES W/ THREADED HOSE CONNECTIONS





3 2" BALL VALVE w/ NPT

18A "A" COMPONENT MIXING
"A" RESIN TOTE
98% AV-100 RESIN + 2% TEA ACCELERATOR

18B "B" COMPONENT MIXING
"B" RESIN TOTE
98% WATER + 2% AMMONIUM PERSULFATE

18 ACRYLAMIDE GROUT, JOINT INJECTION
MATERIAL READY FOR DISCHARGE

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 18B

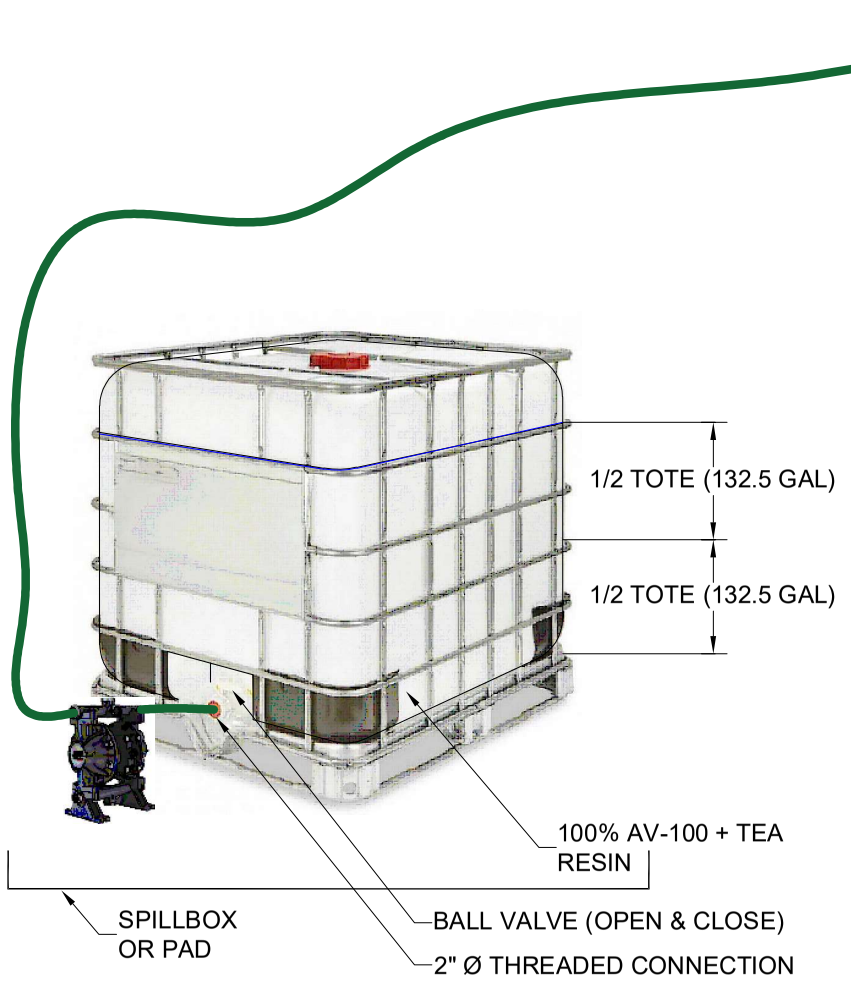
10% SOLUTION GROUT MADE WITH 20% CONCENTRATION OF LIQUID ACRYLAMIDE

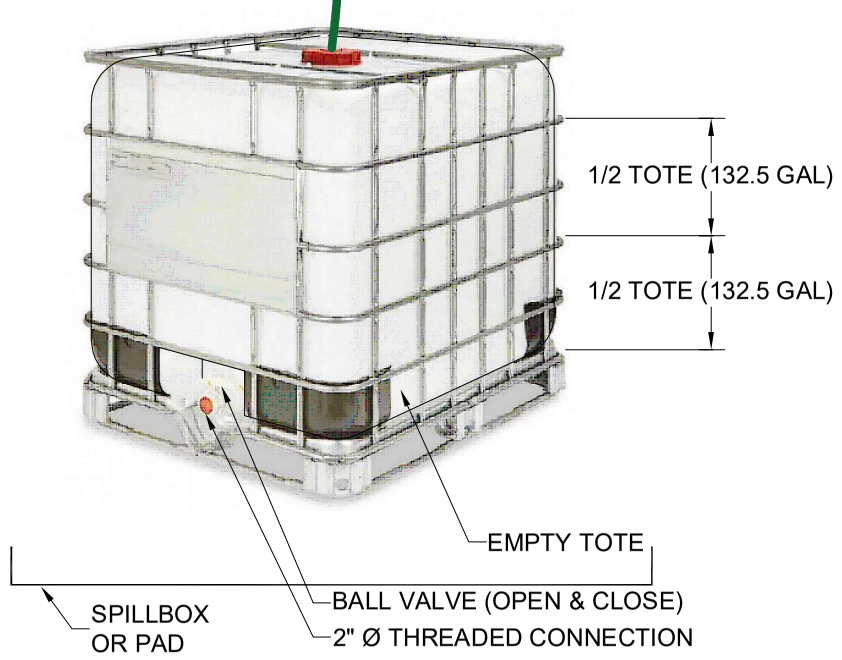
"A" COMPONENT PROPORTIONING

1. POSITION FULL TOTE (2,300 LBS, 265 GALS, 8.66 LBS/GAL), 40% CONCENTRATION, ACRYLAMIDE RESIN ON SPILL PAD
2. PLACE 2" BALL VALVE w/NPT FITTING ONTO DISCHARGE VALVE OF TOTE
3. CONNECT DIAPHRAGM PUMP INTAKE LINE ONTO 2" Ø BALL VALVE w/NPT FITTING
4. PLACE DIAPHRAGM HOSE FROM DIAPHRAGM PUMP INTO EMPTY TOTE ON "B" SIDE, NOTE THAT THIS MATERIAL WILL BE EXTRA "A" SIDE/COMPONENT

"A" COMPONENT PROPORTIONING

1. PLACE CLEAN (WATERBLAST INTERIOR OF TOTE) TOTE ON "B" SIDE OR COMPONENT LOCATION ON SPILLPAD / SPILLBOX
2. ENSURE DISCHARGE VALVE IS WATERTIGHT, SHUT, SECURE AND OPERABLE IF NEEDED
3. PLACE DIAPHRAGM DISCHARGE HOSE INTO TOTE TOP AND FILL TO 1/2 FULL LOCATION (132.5 GAL)
4. PLACE LID BACK ON TOTE UNTIL READY FOR USE





19A "A" COMPONENT PROPORTIONING

"A" RESIN TOTE
98% AV-100 RESIN + 2% TEA ACCELERATOR

19B "B" COMPONENT PROPORTIONING

"B" RESIN TOTE
98% WATER + 2% AMMONIUM PERSULFATE

19 ACRYLAMIDE GROUT, JOINT INJECTION

PROPORTIONING FOR 20% CONCENTRATION

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 19B

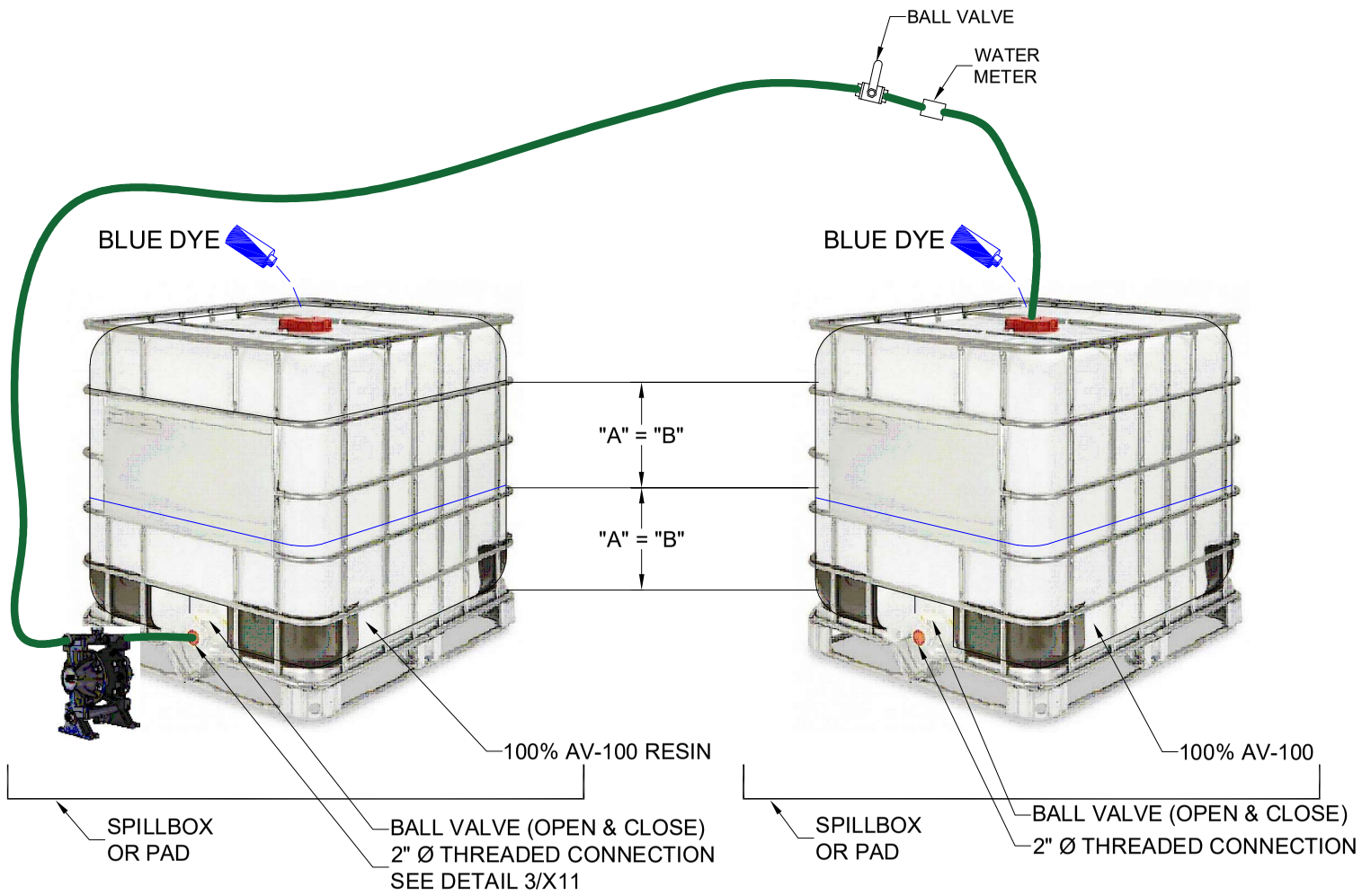
10% SOLUTION GROUT MADE WITH 20% CONCENTRATION OF LIQUID ACRYLAMIDE

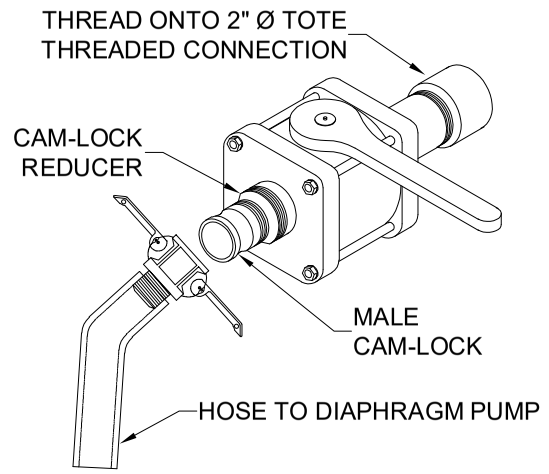
"A" COMPONENT PROPORTIONING

1. PUMP ACRYLAMIDE (40% CONC.) IN FULL TOTE TILL IT IS 1/2 FULL OR EMPTY (132.5 GAL) INTO OTHER TOTE ON "B" SIDE. NOTE THIS MATERIAL WILL BE EXTRA "A" SIDE/COMPONENT
2. UPON COMPLETION, EACH TOTE WILL CONTAIN 132.5 GALLONS AND BE HALF FULL OR EMPTY
3. MARK THIS TOTE AS 132.5 GAL OF 40% CONCENTRATION OF LIQUID ACRYLAMIDE

"A" COMPONENT PROPORTIONING

1. PLACE DIAPHRAGM DISCHARGE HOSE INTO TOTE TOP AND FILL TO 1/2 FULL LOCATION (132.5 GAL)
2. PLACE LID BACK ON TOTE UNTIL READY FOR USE





20C 2" BALL VALVE w/ NPT

20A "A" COMPONENT PROPORTIONING

"A" RESIN TOTE
100% AV-100 RESIN

20B "B" COMPONENT PROPORTIONING

"B" RESIN TOTE
100% AV-100 RESIN

20 ACRYLAMIDE GROUT, JOINT INJECTION

PROPORTIONING FOR 20% SOLUTION, ADDING DYE

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 20B

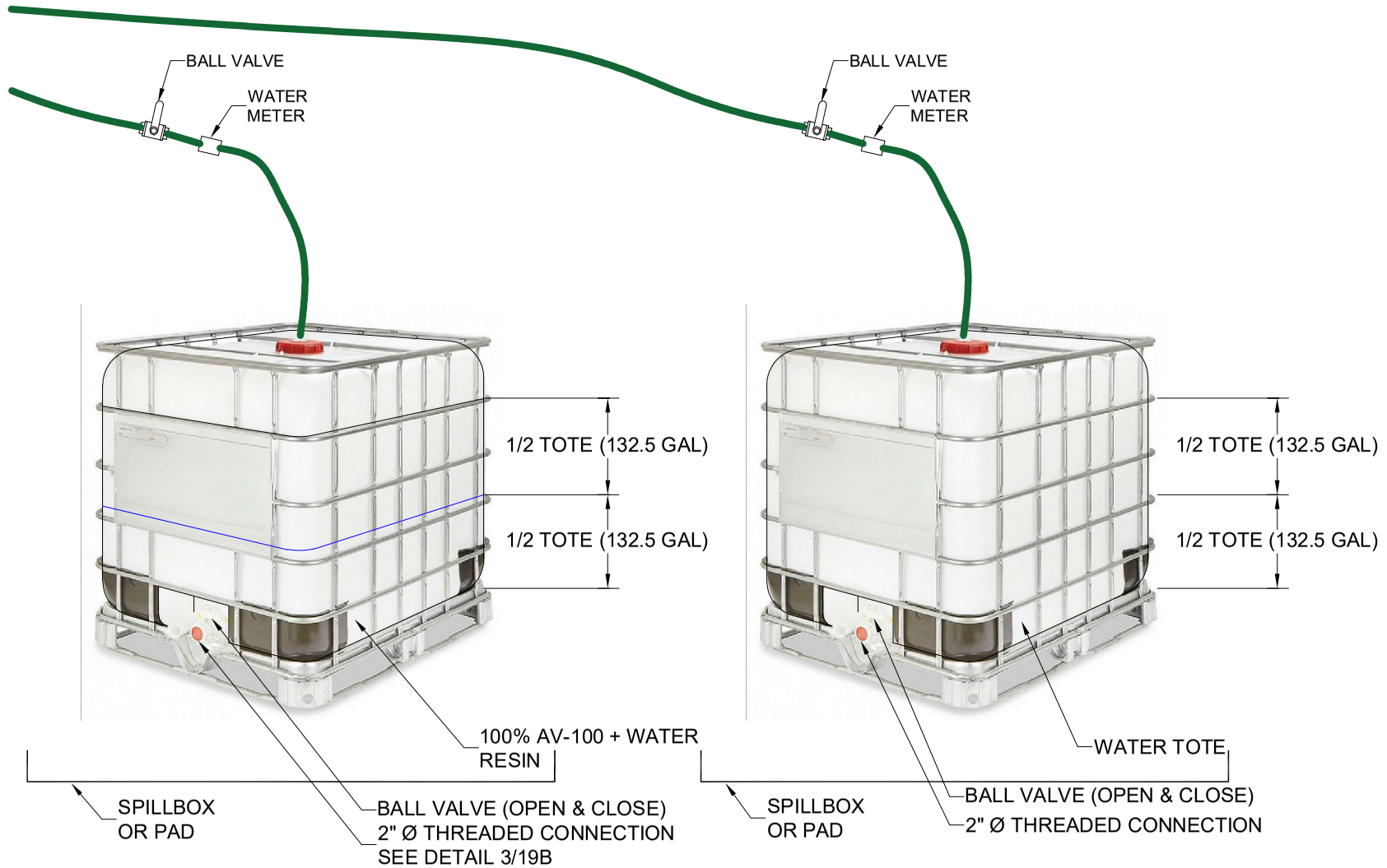
10% SOLUTION GROUT MADE WITH 20% CONCENTRATION OF LIQUID ACRYLAMIDE

"A" COMPONENT PROPORTIONING

1. PLACE 1/2 TOTE (132.5 GAL) ON SPILL PAD
2. FILL TOTE w/ 132.5 GALLONS OF CLEAN WATER TO (265 GAL)

"B" COMPONENT PROPORTIONING

1. PLACE CLEAN EMPTY TOTE ON SPILL PAD
2. PLACE CLEAN (WATERBLAST INTERIOR OF TOTE) TOTE ON "B" SIDE OR COMPONENT LOCATION ON SPILLPAD / SPILLBOX
3. ENSURE DISCHARGE VALVE IS WATERTIGHT, SHUT, SECURE AND OPERABLE IF NEEDED
4. FILL TOTE TO 260 GAL OF CLEAN WATER



21A "A" COMPONENT PROPORTIONING

"A" RESIN TOTE
50% AV-100 RESIN + 50% WATER

21B "B" COMPONENT PROPORTIONING

"B" RESIN TOTE
50% WATER

21 ACRYLAMIDE GROUT, JOINT INJECTION

ADDING WATER FOR PROPORTIONING

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RAYMOND ROAD CULVERT PIPE RESTORATION

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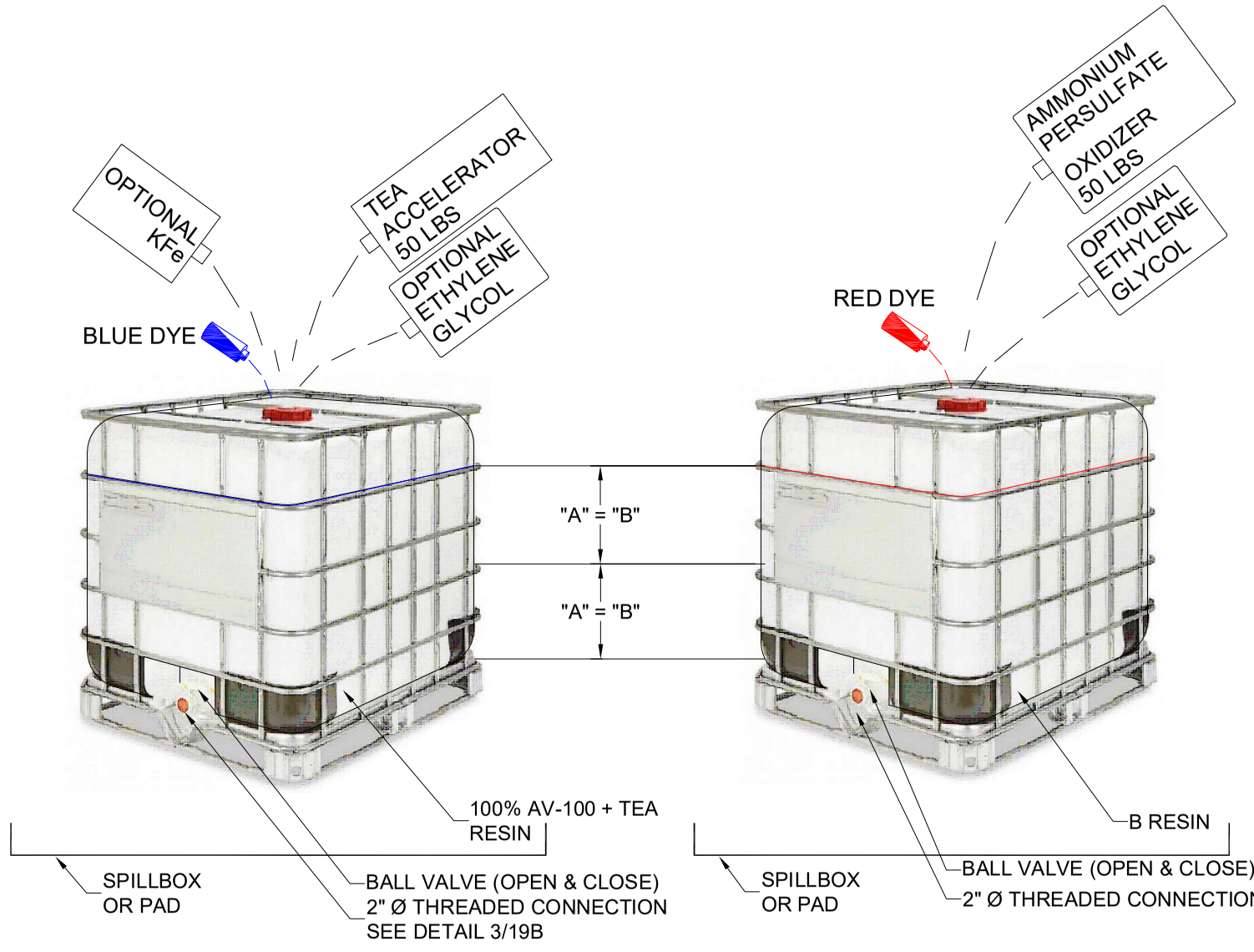
10% SOLUTION GROUT MADE WITH 20% CONCENTRATION OF LIQUID ACRYLAMIDE

"A" COMPONENT PROPORTIONING

1. ADD 1/4 to 1/3 CUP OF BLUE DYE TO TOTE
2. ADD 50 LBS (5 GALS) OF TEA, TRIETHANOLOMINE TO TOTE
3. ADD ETHYLENE GLYCOL AS REQUIRED BY DESIGN
4. ADD KFe TO EXTEND GEL-TIME BY DESIGN
5. AGITATE LIQUID

"B" COMPONENT PROPORTIONING

1. ADD 1/4 to 1/3 CUP OF RED DYE TO TOTE
2. ADD 50 LBS OF AMMONIUM PERSULFATE TO TOTE OF WATER
3. ADD ETHYLENE GLYCOL AS REQUIRED BY DESIGN
4. AGITATE LIQUID



22A "A" COMPONENT PROPORTIONING

"A" RESIN TOTE
49% AV-100 RESIN + 49% WATER + 2% TEA ACCELERATOR

22B "B" COMPONENT PROPORTIONING

"B" RESIN TOTE
98% WATER + 2% AMMONIUM PERSULFATE

22 ACRYLAMIDE GROUT, JOINT INJECTION

ADDING ADDITIONAL COMPONENTS TO MIX

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RAYMOND ROAD CULVERT PIPE RESTORATION

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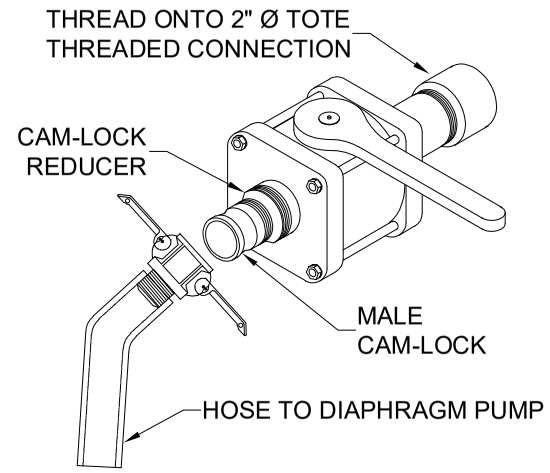
10% SOLUTION GROUT MADE WITH 20% CONCENTRATION OF LIQUID ACRYLAMIDE

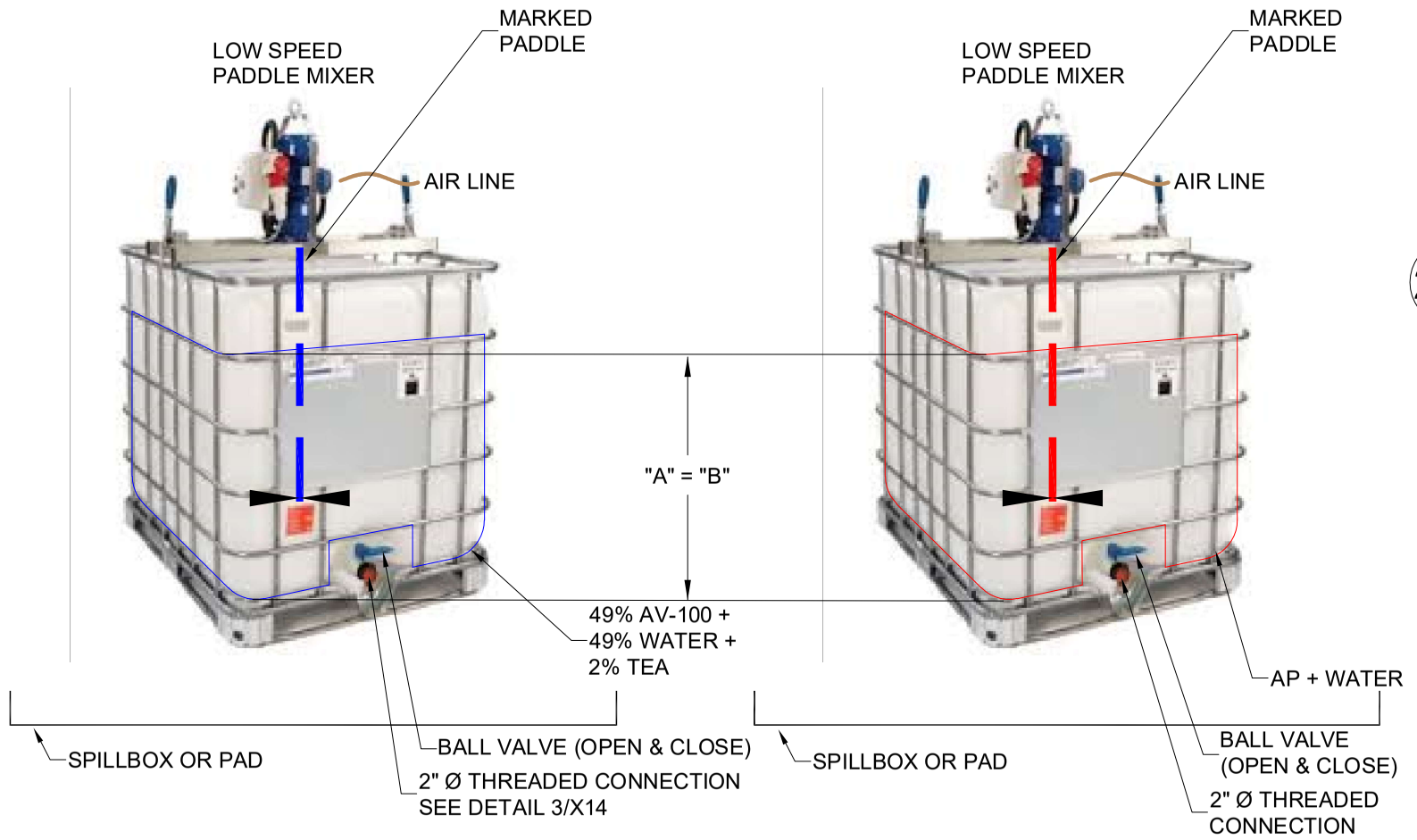
"A" COMPONENT MIXING

1. PLACE LID BACK ON TOTE UNTIL READY FOR USE
2. MARK "A" RESIN PADDLE WITH BLUE LABEL OR TAPE TO ENSURE AGAINST CROSS-CONTAMINATION IN "B" COMPONENT
3. HOOK UP LINE FROM COMPRESSOR TO AIR-OPERATED AGITATOR
4. AGITATE LIQUID AT LOW SPEED TO ENSURE BLENDED MIXTURE
5. HOOKUP 2" BALL VALVE w/ NPT TO TOTE DISCHARGE
6. HOOKUP GROUT PUMP INTAKE TO TOTES w/ THREADED HOSE CONNECTIONS

"B" COMPONENT MIXING

1. MARK "B" RESIN PADDLE WITH RED LABEL OR TAPE TO ENSURE AGAINST CROSS-CONTAMINATION IN "A" COMPONENTS
2. FILL TOTE TO AN EQUAL VOLUME AS ON "A" SIDE
3. HOOK UP LINE FROM COMPRESSOR TO AIR-OPERATED AGITATOR
4. AGITATE LIQUID AT LOW SPEED TO ENSURE BLENDED MIXTURE
5. HOOKUP 2" BALL VALVE W/ NPT TO TOTE DISCHARGE
6. HOOKUP GROUT PUMP INTAKE TO TOTES W/ THREADED HOSE CONNECTIONS





23C 2" BALL VALVE w/ NPT

23A "A" COMPONENT MIXING

"A" RESIN TOTE
49% AV-100 RESIN + 49% WATER + 2% TEA ACCELERATOR

23B "B" COMPONENT MIXING

"B" RESIN TOTE
98% WATER + 2% AMMONIUM PERSULFATE

23 ACRYLAMIDE GROUT, JOINT INJECTION

MATERIAL READY FOR DISCHARGE

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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1/9/2020	1/9/2020	1/9/2020	

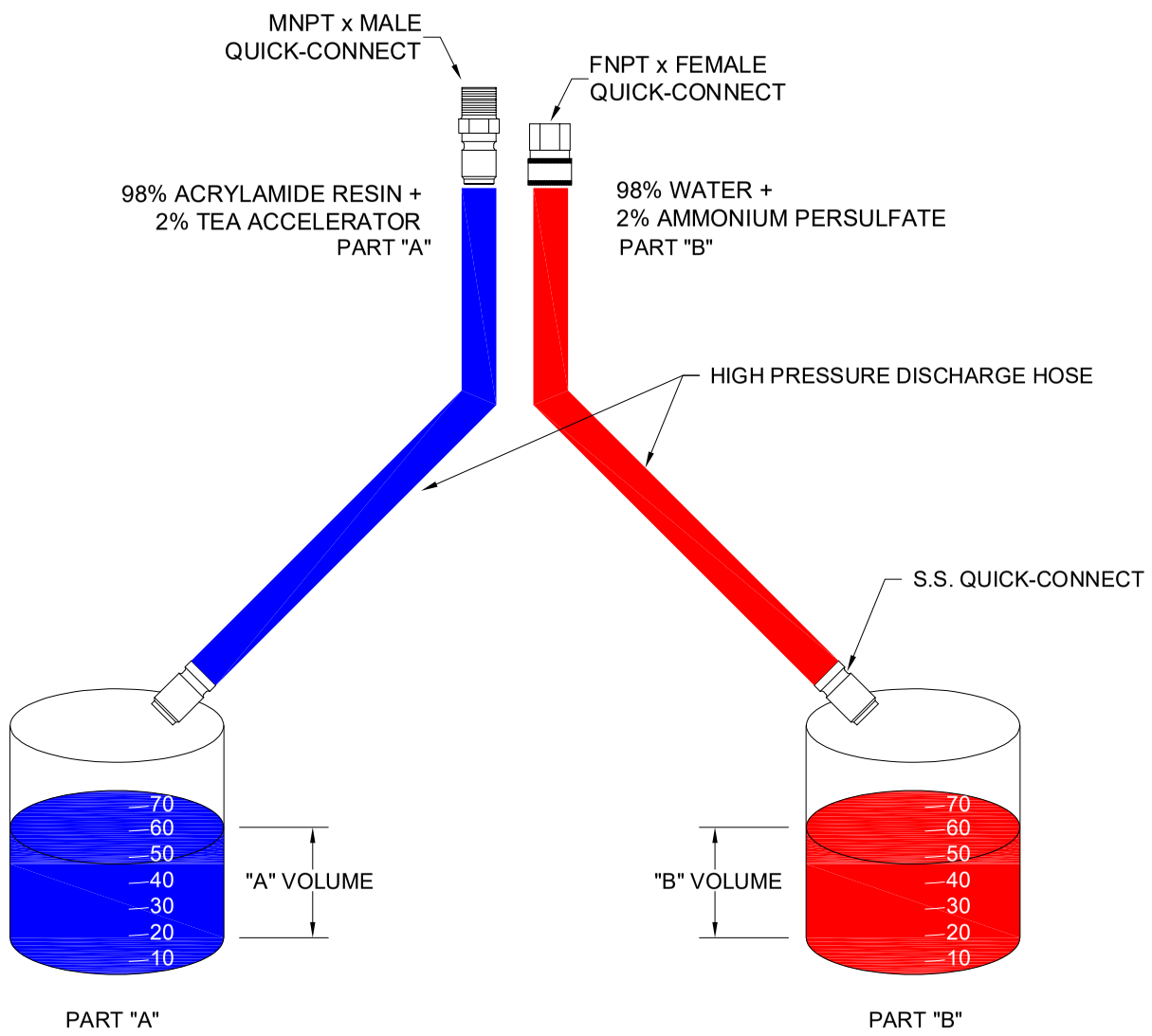
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 23B

1. PRIOR TO PUMPING:
   1.1. DISCONNECT "E" OR "F" ASSEMBLY
   1.2. PUMP PARTS "A" & "B" INTO MEASURING CUPS TO ENSURE PROPER 1-TO-1 RATIO, TOLERANCE MAY BE 10% EITHER WAY
   1.3. ADJUST PUMP STROKE LENGTH IF NOT IN RATIO OF 1-TO-1
2. RATIO BALANCE CAN BE INFLUENCED BY PARTICLES OR DEBRIS BUILD UP IN VALVES OF PUMP



24 ACRYLAMIDE GROUT, JOINT INJECTION

QA / QC, 1-to-1 RATIO CHECK

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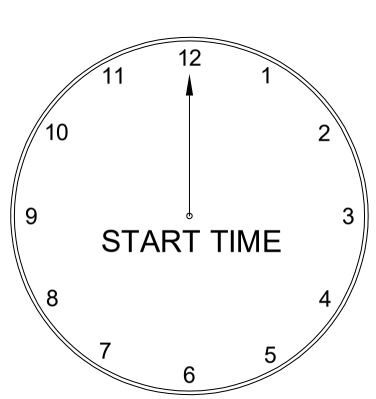
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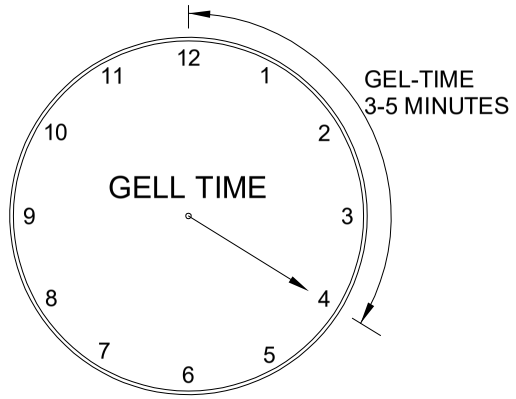
RAYMOND ROAD CULVERT PIPE RESTORATION

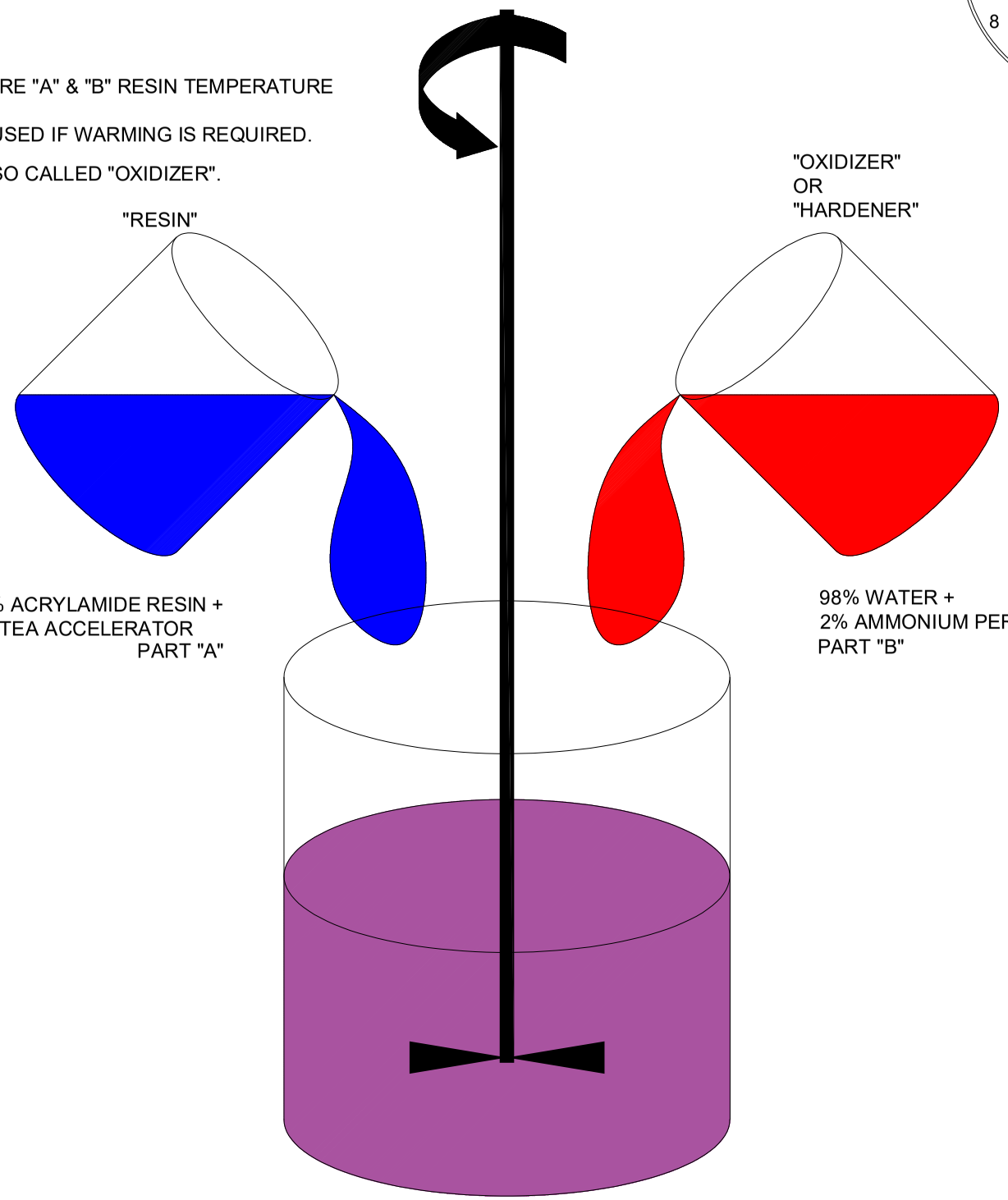
SHEET: 24B

1. COLLECT EQUAL VOLUME "A" & "B" COMPONENTS AND MIX TOGETHER, NOTE START TIME.
2. AFTER SHORT PERIOD (30 SECONDS TO 3 MINUTES) GROUT VISCOSITY INCREASES.
3. RATHER QUICKLY GROUT SOLIDIFIES INTO A SOLID MASS. NOTE GEL TIME.
4. IF GEL TIME IS TOO SHORT:
   - 4.1. REDUCE TEA BY 20% INTO PART "A"
   - 4.2. REDUCE HARDENER IN PART "B" BY 20%.
   - 4.3. MEASURE NEW GEL TIME.
5. IF GEL TIME IS TOO LONG:
   - 5.1. INCREASE TEA BY 20% INTO PART "A"
   - 5.2. INCREASE HARDENER IN PART "B" BY 20%
   - 5.3. MEASURE NEW GEL TIME
6. GEL-TIME IS INFLUENCED BY FLUID TEMPERATURE "A" & "B" RESIN TEMPERATURE TO THIS CAN BE VARIED FROM 40° TO 120° F.
7. PAIL AND/OR DRUM HEATERS ARE COMMONLY USED IF WARMING IS REQUIRED.

* HARDENER IS CALLED AMMONIUM PERSULFATE, ALSO CALLED "OXIDIZER".







GEL TIME INFLUENCED BY:

1. TEMPERATURE OF LIQUIDS "A" & "B"
2. pH OF WATER ON "B" SIDE
3. IRON CONTENT IN WATER IN "B" SIDE
4. CONCENTRATIONS OF ACCELERATOR AND OXIDIZER IN TOTES

25 ACRYLAMIDE GROUT, JOINT INJECTION

GEL TIME CHECK

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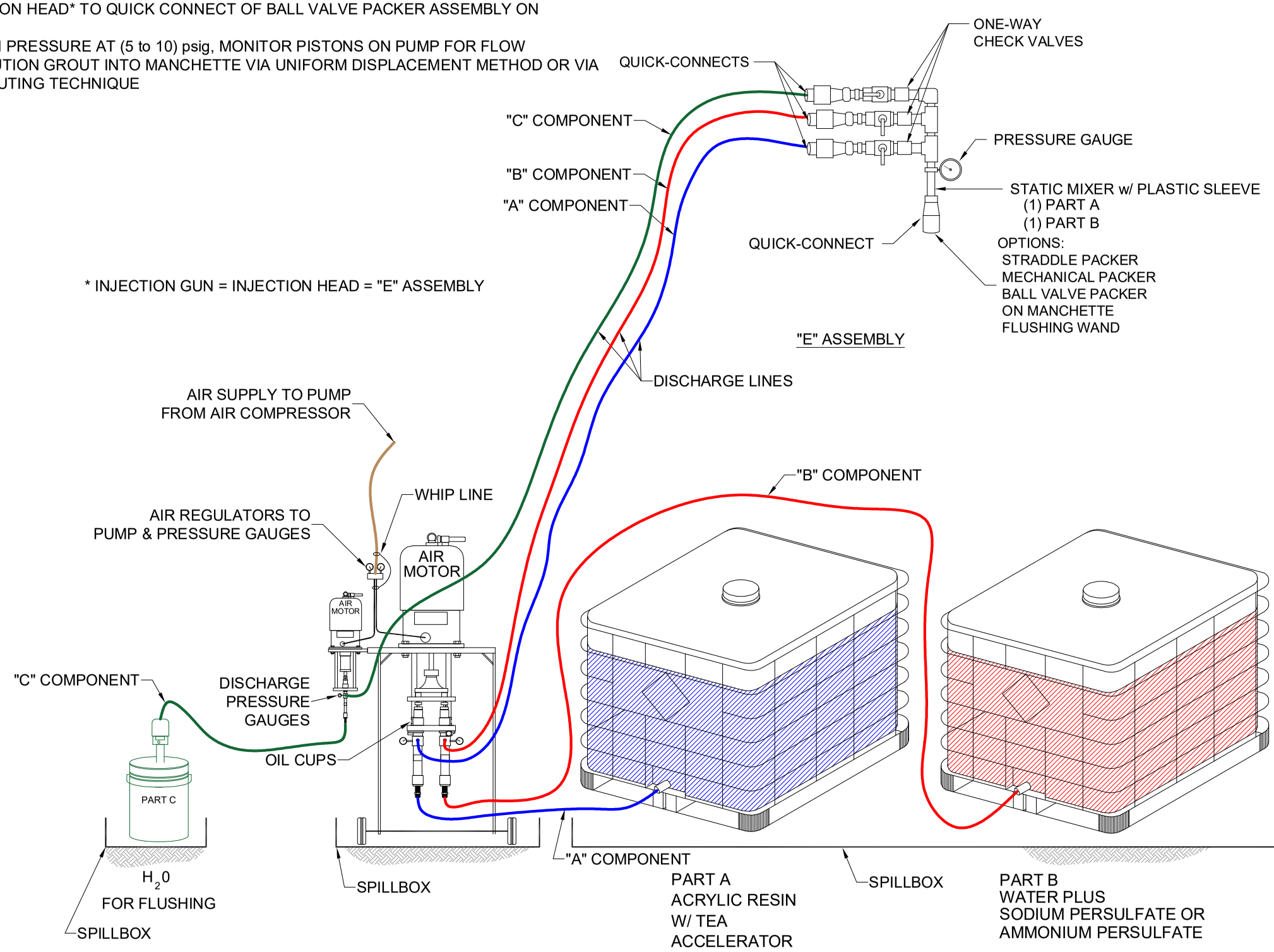
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 25B

1. REFER TO SHEET 24B AND 25B, FOR GEL-TIME CUP TEST, AND RATIO CHECK
2. NOTE: STATIC MIXER NEEDS TO BE FLUSHED WITH WATER PRIOR TO GEL-TIME REACTION
3. TURN ON AIR PRESSURE TO CHEMICAL GROUT SYSTEM PUMP, TURN OFF AIR PRESSURE TO FLUSHING PUMP
4. REGULATE AIR PRESSURE TO OBTAIN A STEADY FLOW OF MATERIAL THROUGH INJECTION GUN*
5. HOOK UP INJECTION HEAD* TO QUICK CONNECT OF BALL VALVE PACKER ASSEMBLY ON MANCHETTE
6. START INJECTION PRESSURE AT (5 to 10) psig, MONITOR PISTONS ON PUMP FOR FLOW
7. DISCHARGE SOLUTION GROUT INTO MANCHETTE VIA UNIFORM DISPLACEMENT METHOD OR VIA BOTTOM-UP GROUTING TECHNIQUE



* NOTE - RE-CIRCULATING DISCHARGE LINES NOT SHOWN FOR CLARITY

26 ACRYLAMIDE GROUT, JOINT INJECTION
PUMPING

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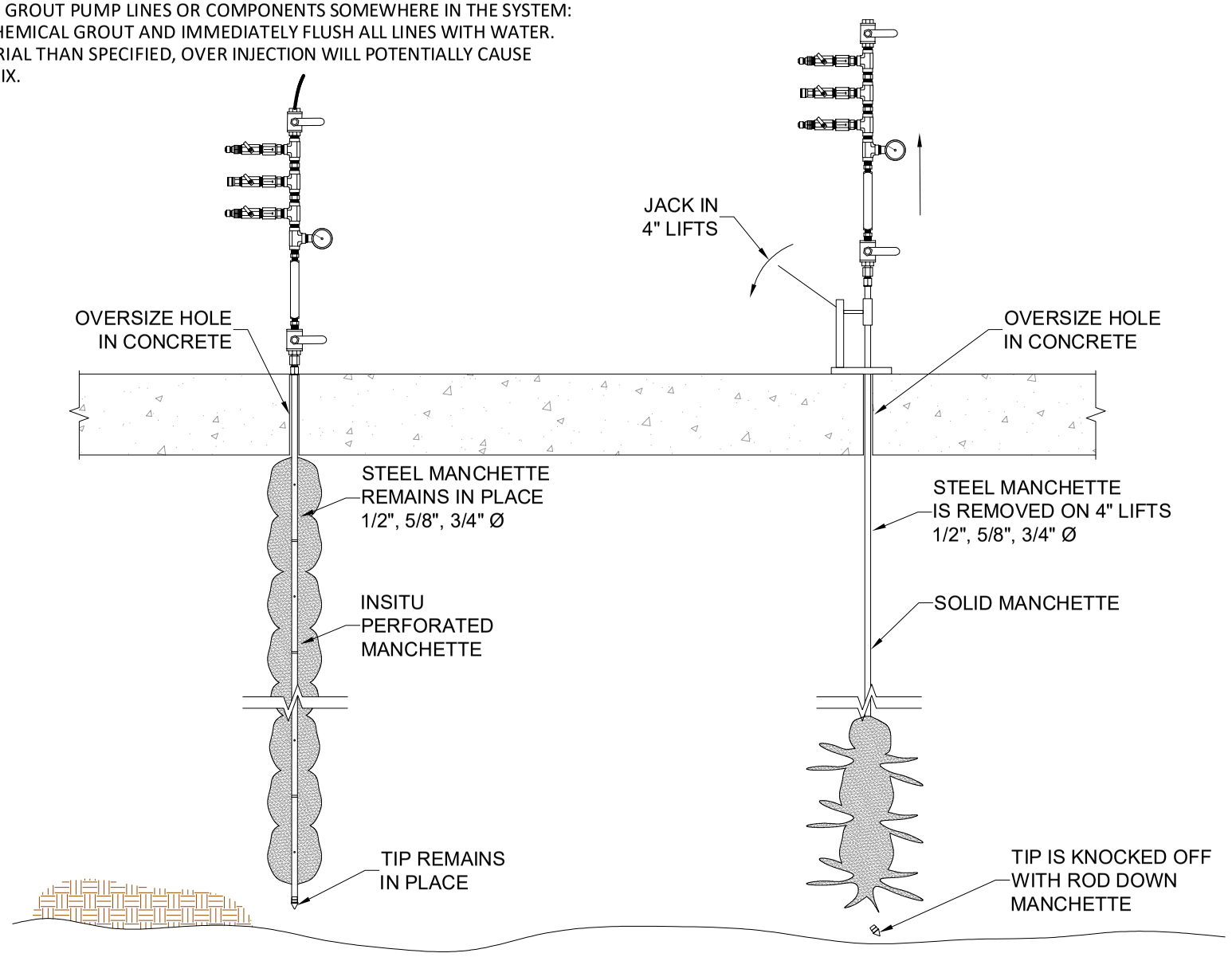
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 26B

1. TWO CLASSIC METHODS OF MANCHETTE INJECTION ARE:
   1.1. UNIFORM DISPURSEMENT GROUTING
   1.2. BOTTOM-UP GROUTING
2. CONTINUE PUMPING UNTIL SPECIFIED GROUT QUANTITY IS DELIVERED INTO POSITION;
   2.1. IF PRESSURE GAUGE SPIKES UP DURING PUMPING, ONE OF THE FOLLOWING ITEMS HAS OCCURRED:
      2.1.1. THE CHEMICAL GROUT HAS SUDDENLY GELLED AND CURED IN THE MANCHETTE SLEEVE, CONSIDER THIS A "DEAD" HOLE,
         2.1.1.1. MOVE TO NEXT MANCHETTE AND SPEED UP THE INJECTION RATE,
         2.1.1.2. IF PLUGGING CONTINUES IN MANCHETTE, NOTE AS "DEAD" HOLE AND CHANGE FORMULATION TO LONGER GEL TIME OF "A" AND "B" COMPONENTS, AND
         2.1.1.3. NEW INJECTION HOLES WILL BE REQUIRED NEXT TO THE "DEAD" HOLES.
      2.1.2. THE SOIL ZONE IS FULL AND CANNOT TAKE MORE GROUT,
         2.1.2.1. IF GROUTING CONTINUES UNDER HIGHER PRESSURES, SOIL FRACKING WILL OCCUR AND SOIL UPLIFT MAY START.
      2.1.3. THERE IS A PLUG IN THE GROUT PUMP LINES OR COMPONENTS SOMEWHERE IN THE SYSTEM:
         2.1.3.1. STOP INJECTING CHEMICAL GROUT AND IMMEDIATELY FLUSH ALL LINES WITH WATER.
   2.2. DO NOT INJECT MORE MATERIAL THAN SPECIFIED, OVER INJECTION WILL POTENTIALLY CAUSE FRACKING OF THE SOIL MATRIX.
   2.3. IF UNREACTED CHEMICAL GROUT COMES TO THE SURFACE OTHER THAN IMMEDIATELY AT THE MANCHETTE PENETRATION INTO THE SOIL, NOTE THE FOLLOWING
      2.3.1. THE SOIL ZONE IS FULL AND CANNOT TAKE MORE GROUT,
         2.3.1.1. IF GROUTING CONTINUES UNDER HIGHER PRESSURES, SOIL FRACKING WILL OCCUR AND SOIL UPLIFT MAY START.
      2.3.2. THERE IS A PLUG IN THE BOTTOM PART OF THE MANCHETTE AND ALL GROUT IS BEING DISBURSED CLOSE TO THE SURFACE,
         2.3.2.1. IMMEDIATELY FLUSH MANCHETTE WITH WATER AND RUN FLUSHING WAND DOWN MANCHETTE TO ENSURE IT IS OPEN TO THE BOTTOM.



27A UNIFORM PLACEMENT

27B BOTTOM-UP GROUTING
PUMPING

27 ACRYLAMIDE GROUT, JOINT INJECTION
TYPES OF MANCHETTE INJECTION

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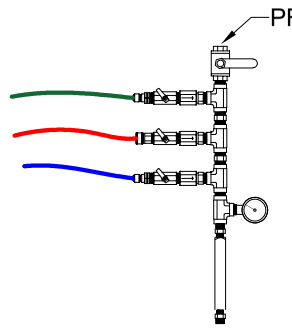
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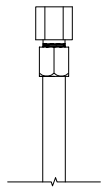
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 27B

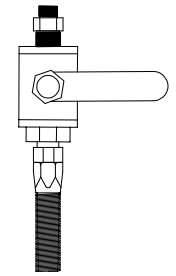
1. UPON COMPLETION OF PRESSURE INJECTION OPERATIONS, FLUSH PUMPS WITH DETERGENT/SOAP AND WATER INTO SPILL PAIL
2. ENSURE THE FOLLOWING ITEMS ARE FLUSHED OUT:
   - 2.1. PUMP INTAKE LINES, DISCHARGE LINES, AND RECIRCULATING LINES
   - 2.2. E-ASSEMBLY
   - 2.3. FERRULE FITTINS ON MANCHETTES
   - 2.4. REMOVABLE PACKERS



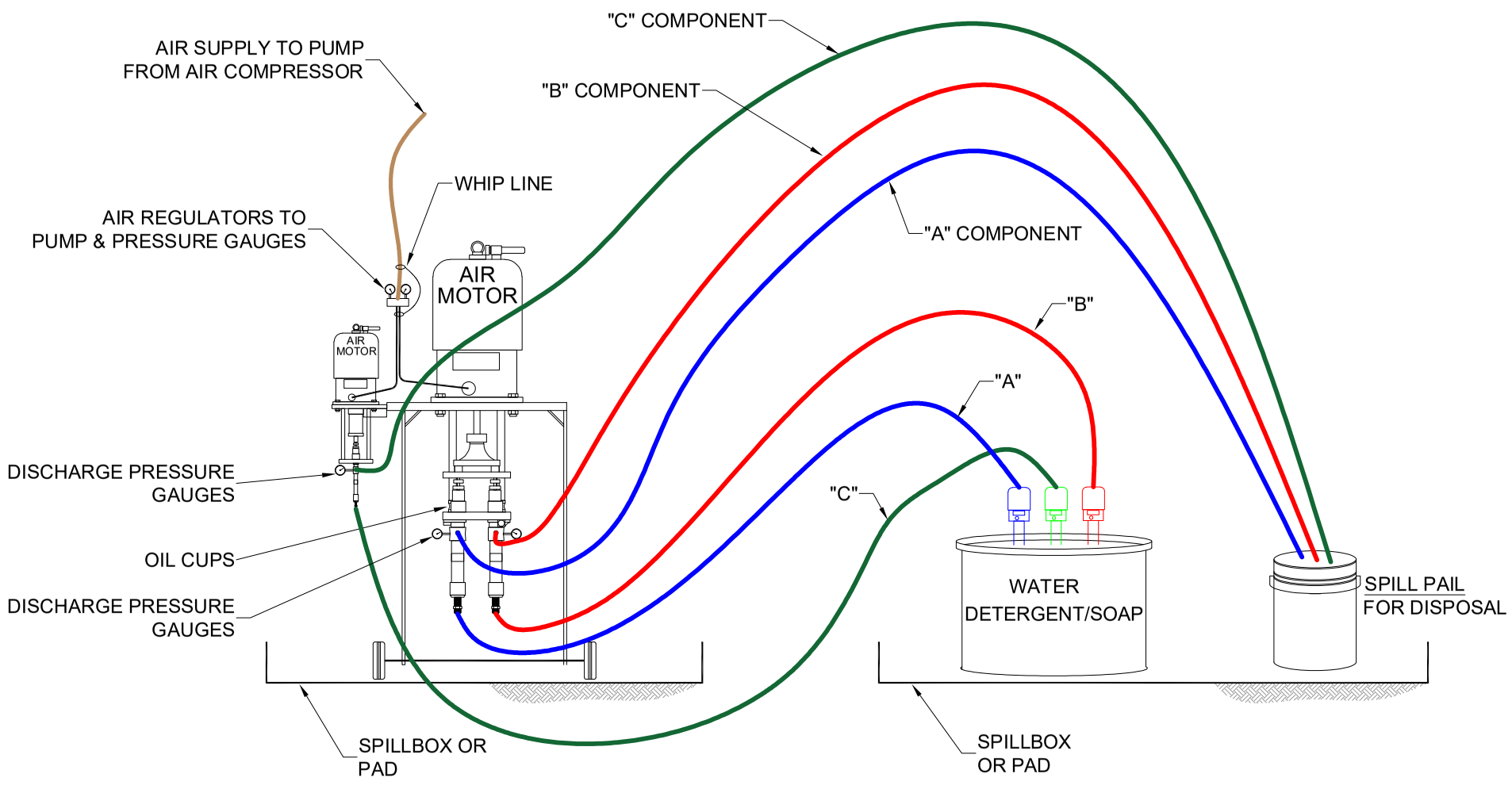
28A E-ASSEMBLY



28B FERRULE FITTINGS



28C REMOVABLE PACKERS



28 ACRYLAMIDE GROUT, JOINT INJECTION

DETERGENT WATER FLUSHING GROUT PUMP
GROUT PUMP CLEANUP
NOTE: RE-CIRCULATING DISCHARGE LINES NOT SHOWN FOR CLARITY

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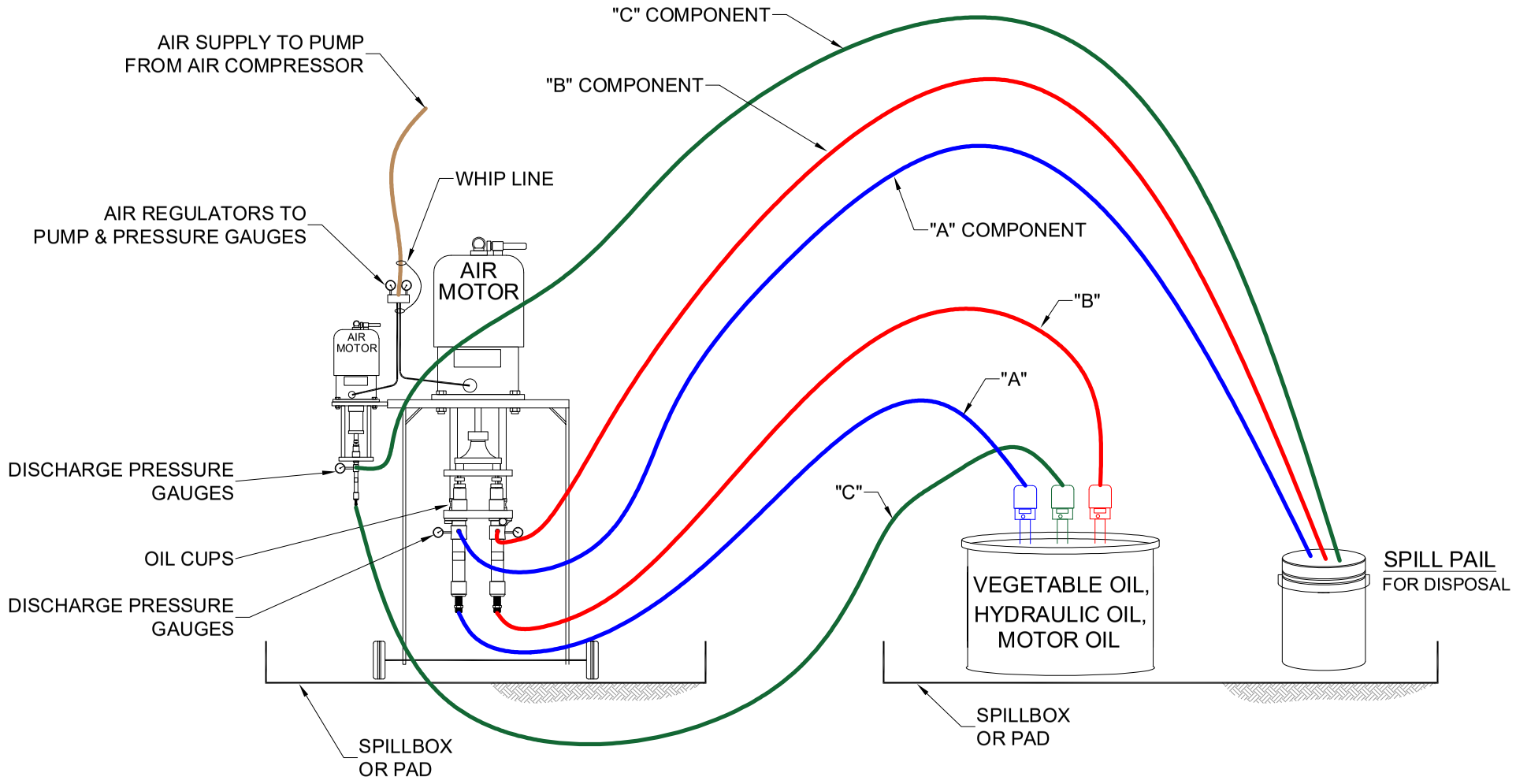
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 28B

1. AFTER FLUSHING w/ DETERGENT AND WATER, PUMP VEGETABLE, OR MOTOR OIL IN (CHEMICAL GROUT SYSTEMS (CGS) PRESSURE INJECTION PUMP AND ATTACHED FLUSHING PUMP) SYSTEM FOR STORAGE OR UNTIL NEXT USAGE.



29 ACRYLAMIDE GROUT, JOINT INJECTION

OIL INDUCTION, PREPARING FOR STORAGE
NOTE: RE-CIRCULATING DISCHARGE LINES NOT SHOWN FOR CLARITY

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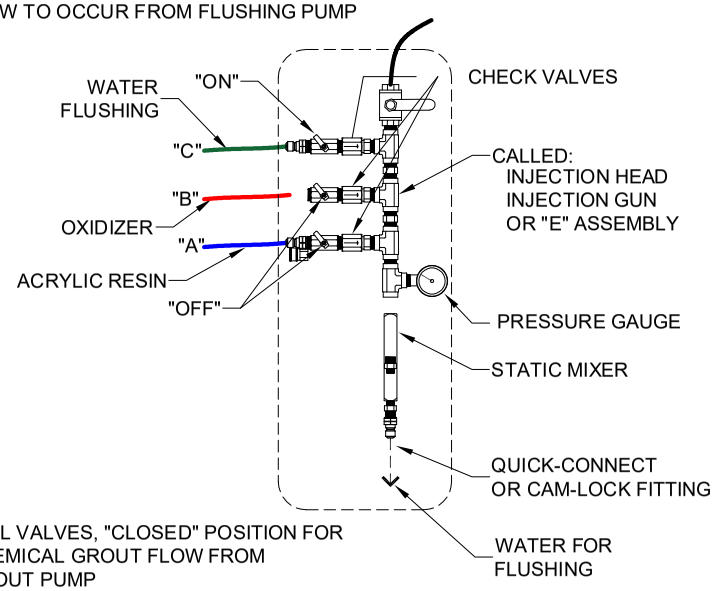
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 29B

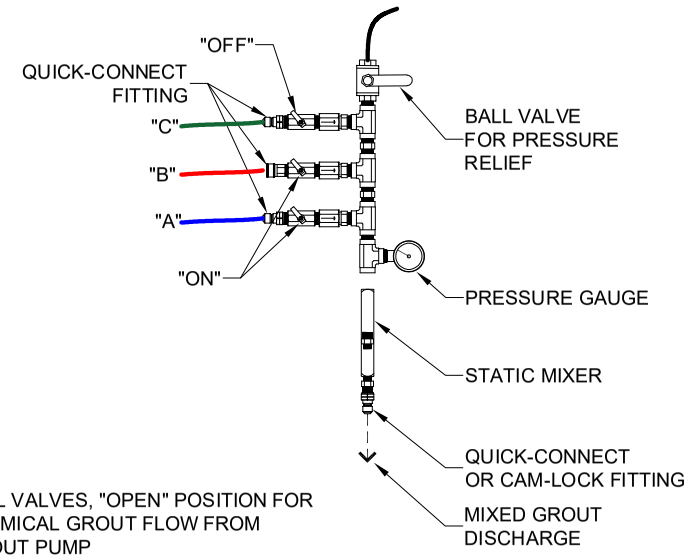
WATER FLUSHING LINE IN OPEN POSITION, MEANING PRESSURIZED WATER FLOW TO OCCUR FROM FLUSHING PUMP



BALL VALVES, "CLOSED" POSITION FOR CHEMICAL GROUT FLOW FROM GROUT PUMP

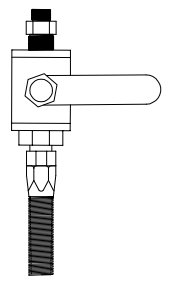
"E" ASSEMBLY, FLUSHING OPERATION

WATER FLUSHING LINE IN CLOSED, MEANING NO WATER FLOW FROM FLUSHING PUMP

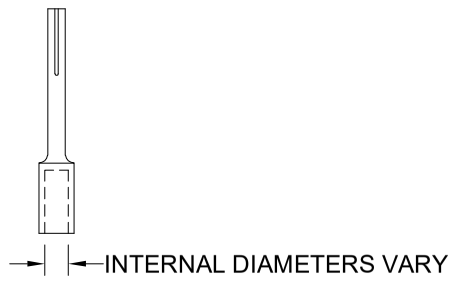


BALL VALVES, "OPEN" POSITION FOR CHEMICAL GROUT FLOW FROM GROUT PUMP

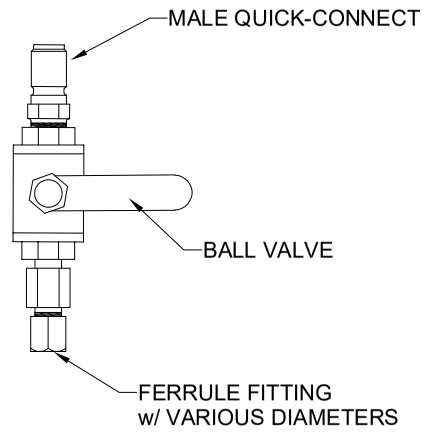
"E" ASSEMBLY, GROUTING OPERATION



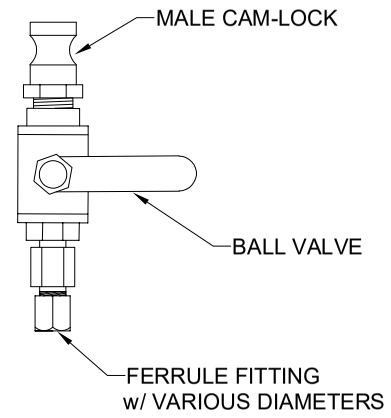
REMOVABLE PACKER



MANCHETTE DRIVER
w/ VARIOUS INTERNAL DIAMETERS



QUICK-CONNECT / BALL VALVE / FERRULE



CAM / BALL VALVE / FERRULE

30 ACRYLAMIDE GROUT, JOINT INJECTION
EQUIPMENT HARDWARE & ACCESSORIES

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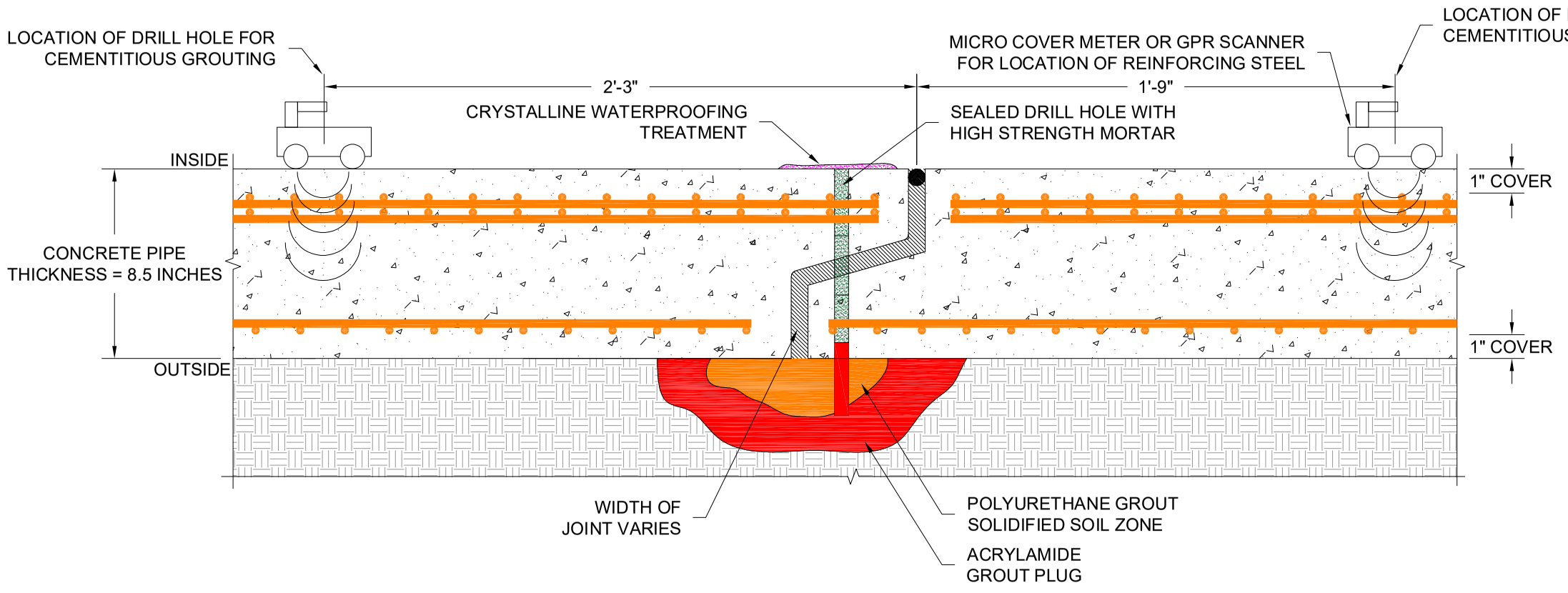
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 30B

GENERAL CONDITIONS:

1. EXAMINE TUNNEL MANHOLES AND PORTALS FOR ACCESS AND EGRESS, OBSERVE MANHOLE COVERS DIMENSIONS FOR OBSTRUCTIONS:
   - 1.1. COORDINATE SAFETY PLAN TO INCLUDE MANAGEMENT OF MANCHETTE TOPS TO AVOID TRIP HAZARDS TO TRADESMEN
   - 1.2. COORDINATE ACCESS/EGREE PLAN IN CASE OF HIGH WATER, EXCESS CARBON DIOXIDE, LACK OF LIGHTING AND/OR OTHER ISSUES THAT MAY REQUIRE UNPLANNED EVACUATION OF CULVERT PIPE
   - 1.3. COORDINATE WORKING TIMES TO ENSURE STORM WATER DRAINAGE DOES NOT INTERFERE WITH GROUTING OPERATIONS BEYOND MANAGED WATER RE-ROUTING
   - 1.4. COORDINATE EYEWASH STATIONS FOR POTENTIAL CONTAMINANTS DURING GROUTING
   - 1.5. COORDINATE ELECTRICAL AND COMPRESSED AIR SUPPLY FOR GROUTING EQUIPMENT
   - 1.6. ENSURE PROJECT TEAM IS COORDINATED WITH WEATHER FORECASTS AND CURRENT CONDITIONS
   - 1.7. ENSURE WATER DIVERSION PLAN IS APPROVED BY OWNER
   - 1.8. FOLLOW ALL OSHA REQUIREMENTS FOR CONFINED SPACE WORK
   - 1.9. ENSURE:
     - 1.9.1. PROPER & ADEQUATE LIGHTING & ELECTRICAL SUPPLY
     - 1.9.2. PROPER & ADEQUATE FRESH AIR-SUPPLY
     - 1.9.3. PROPER & ADEQUATE AIR QUALITY MONITORING
     - 1.9.4. PROPER & ADEQUATE EYE WASH STATIONS ARE SETUP
   - 1.10. IDENTIFY ALL BURIED UTILITIES WITHIN IMMEDIATE GROUT ZONE AREA.
   - 1.11. IDENTIFY STORM OR SANITARY SEWER PIPES WITHIN 10 FEET OF GROUT ZONE, AND ESTABLISH SOME CRITERIA TO MONITOR EXISTING PIPING DURING CHEMICAL GROUTING TO ENSURE NO STRAY GROUT MIGRATION OCCURS.

1. CLEAN DRY SUBSTRATES IN GROUT ZONE
2. USE GPR OR EQUAL TO LOCATE STEEL REINFORCING
3. MARK DRILL / CORE LOCATIONS ON CONCRETE SUBSTRATE AS FOLLOWS:
   - 3.1. LOCATE DRILL / CORE HOLES 1'-9" FROM JOINT ON ONE SIDE AND 2'-3" ON THE OTHER SIDE,
   - 3.2. LOCATE DRILL / CORE HOLES AS SHOWN ON DETAIL 2C.



1 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION
PREPERATION, LOCATION OF STEEL REINFORCING

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RAYMOND ROAD CULVERT PIPE RESTORATION

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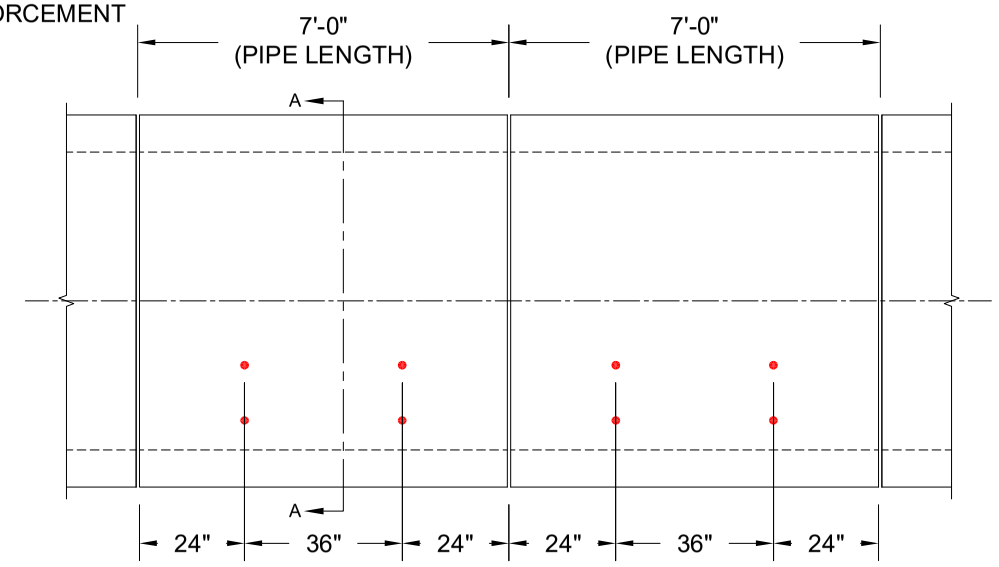
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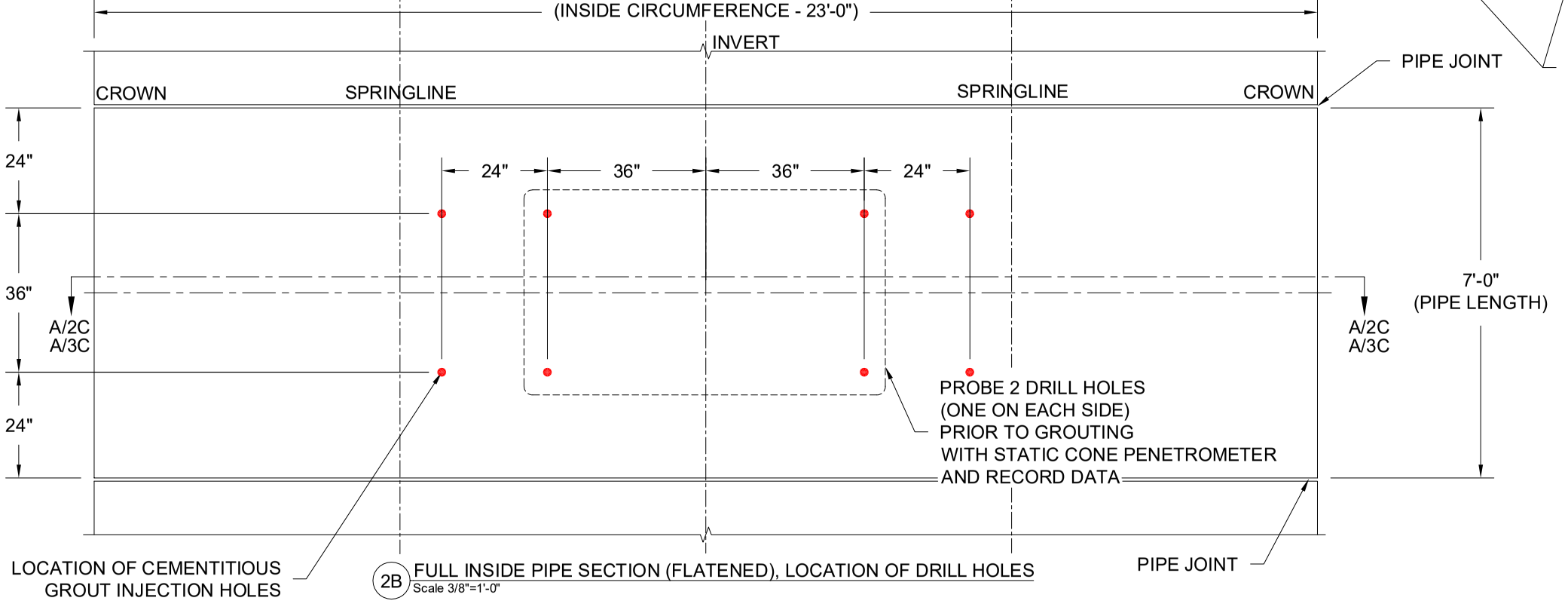
SHEET: 1C

ULTRA-FINE CEMENTITIOUS GROUTING

1. MARK GROUT HOLE LOCATIONS FOR DRILLING AS SHOWN ON THE PLANS
   - 1.1. CEMENTITIOUS GROUT HOLES SHALL BE LOCATED AT TUNNEL HAUNCH AREAS (ON EACH SIDE OF INVERT)
   - 1.2. DRILL HOLES SHALL BE LOCATED AT 36" AND 60" TRANSVERSE AND CIRCUMFERENTIALLY FROM INVERT ON EACH SIDE
   - 1.3. DRILL HOLES SHALL BE ALSO LOCATED @ 24" FROM EACH END PIPE
   - 1.4. USE GPR OR SIMILAR METHODS FOR LOCATING STEEL REINFORCING BARS/GRIDS/MESH IN CONCRETE CULVERT PRIOR TO DRILLING
   - 1.5. DRILL HOLES CAN BE ADJUSTED 4 INCHES IN ANY DIRECTION TO AVOID STEEL REINFORCEMENT

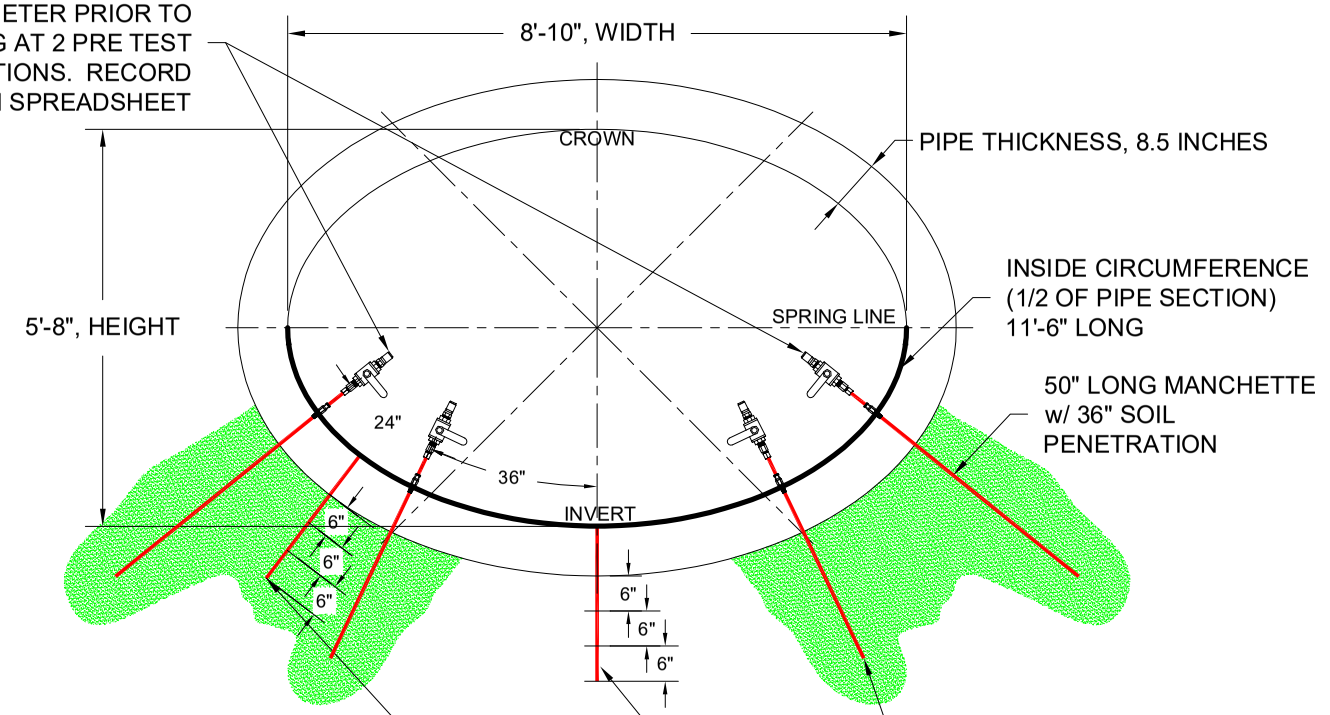


2A ELEVATION, LOCATION OF DRILL HOLES
N.T.S.



2B FULL INSIDE PIPE SECTION (FLATENED), LOCATION OF DRILL HOLES
Scale 3/8"=1'-0"

TEST SOIL w/ STATIC CONE PENETROMETER PRIOR TO GROUTING AT 2 PRE TEST HOLE LOCATIONS. RECORD DATA ON SPREADSHEET



A SECTION
Scale 3/8"=1'-0"

1 POST GROUT HOLE TEST LOCATION, TEST SOIL @ 6" INTERVALS w/ STATIC CONE PENETROMETER AFTER GROUT HAS SETUP. RECORD DATA ON SOIL IMPROVEMENT. ALTERNATE 1 ANGLED DRILL EVERY PIPE AND VERTICAL HOLE EVERY OTHER PIPE FOR TESTING. SEE SHEET 4C FOR MOCKUP PROTOCOL.

2 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION
DRILL HOLE LOCATIONS

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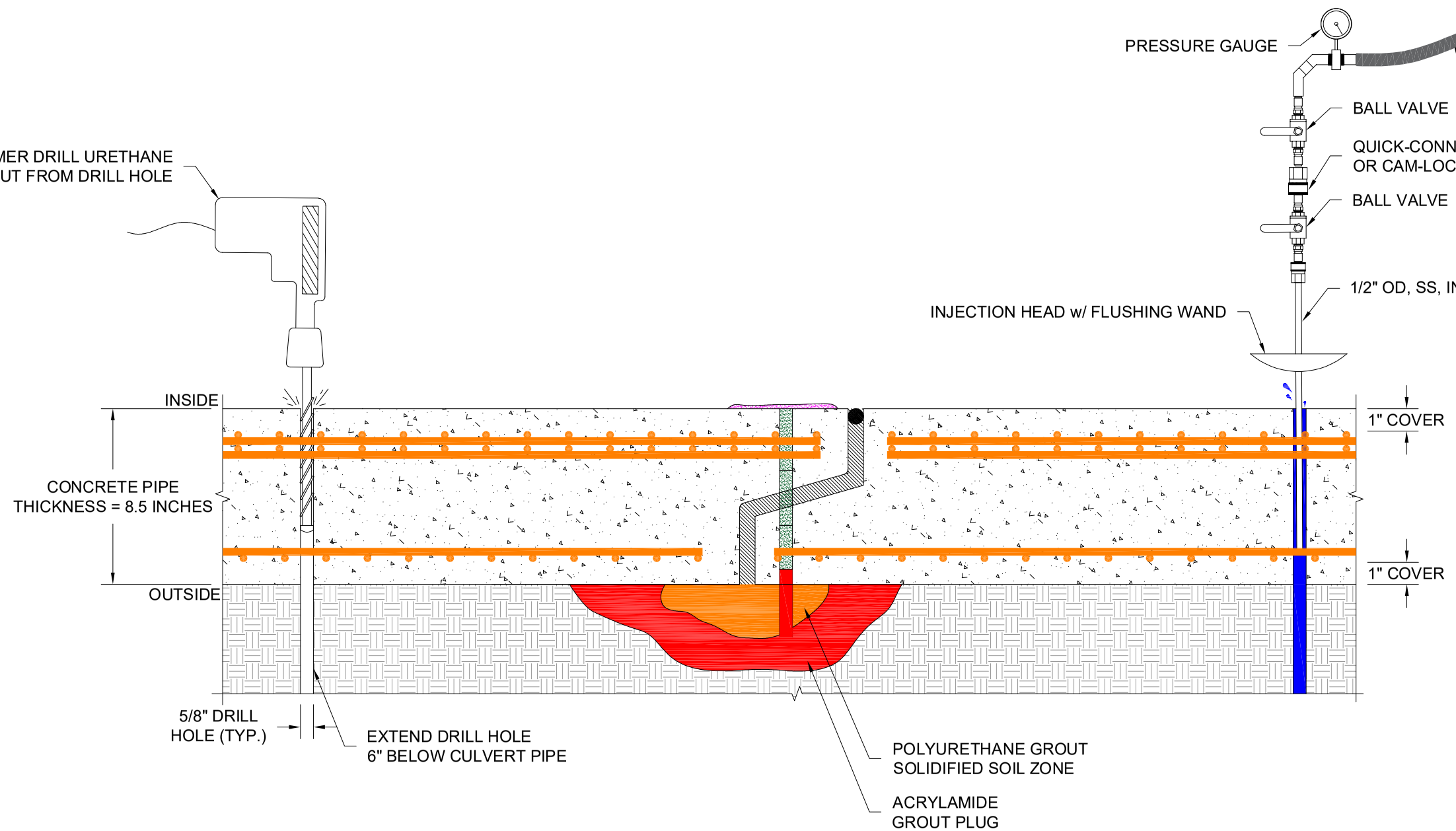
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 2C

1. DRILL 3/4" Ø HOLES THROUGH CONCRETE PIPE WITH PROGRESSING LENGTH BITS AS REQUIRED TO A DEPTH AS NOTED ON THE PLANS
   - 1.1. COLLECT DRILLING DEBRIS AND SOIL PARTICLES VIA VACUUM AROUND DRILL HOLES, AND
   - 1.2. AIR OR WATERBLAST DRILL HOLE SIDES TO CLEAN, ENSURE OSHA SILICA DUST PROTOCOLS ARE FOLLOWED
2. PENETRATE DRILL 6" BELOW PIPE EXTERIOR, INTO SOIL
3. FLUSH DRILL / CORE HOLE WITH PRESSURIZED WATER.



3 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION

DRILL HOLE & WATER FLUSHING DRILL HOLES

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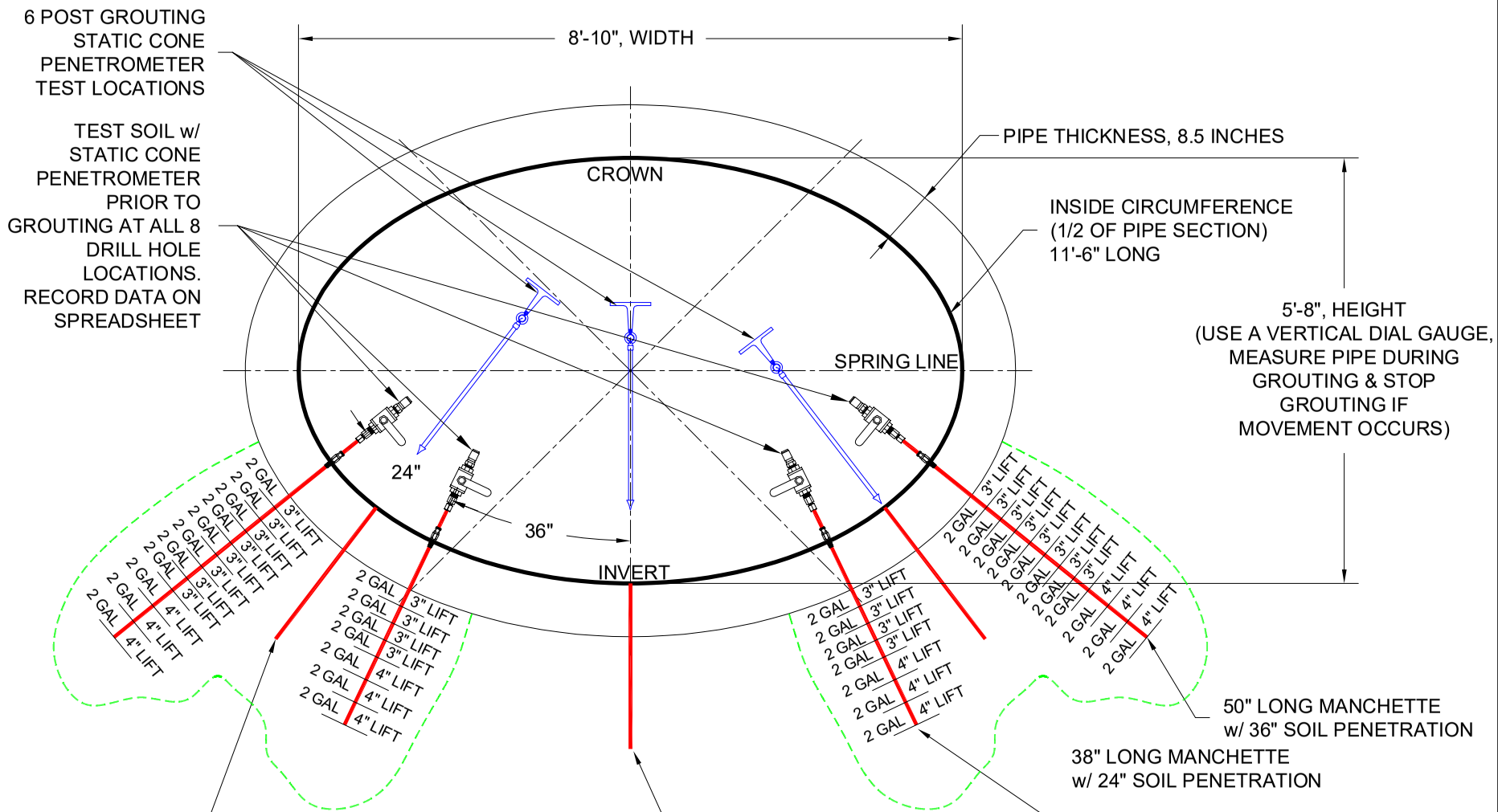
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 3C

1. INSERT STATIC CONE PENETROMETER DOWN DRILL HOLE 36 INCHES CIRCUMFERENTIALLY OFF INVERT, (24-INCH-DEEP GROUT ZONE) AND MEASURE RESISTANCE AT 12 INCH AND 18 INCH DEPTHS, RECORD DATA ON SPREADSHEET
2. INSERT PLASTIC SLEEVE ON TAPERED SHAFT OF "JA" PACKER AND SECURE INTO POSITION AT DRILL HOLE, ENSURE RUBBER O-RING IS IN PLACE AND NOT SEVERELY WORN OR DAMAGED
3. PLACE METAL DRIVE TIP ON 1/2" Ø MANCHETTE
4. PLACE 1/2" Ø MANCHETTE INTO "JA" PACKER AND ALIGN WITH DRILL HOLE
5. DRIVE 1/2" Ø SOLID MANCHETTE, WITH STEEL TIP, WITH HAMMER-DRILL DRIVING TOOL OR BY HAND PRESSURE
6. IF RESISTANCE IS ENCOUNTERED DUE TO BOULDERS, COBBLES, OR COARSE AGGREGATE BACKFILL, USE SOLID STEEL ROD OR 3/8" HAMMER-DRILL BIT TO CLEAR PASSAGE
7. DRIVE MANCHETTES TO DEPTHS SHOWN, 24 INCHES INTO SOIL-CLOSEST TO INVERT, 36 INCHES INTO SOIL FARTHEST FROM INVERT. NOTE THE FOLLOWING:
   - 7.1. MANCHETTE LENGTH OF 24 INCHES INTO SOIL, 8.5 INCHES THRU CONCRETE PIPE SECTION, 5.5 INCHES INTERIOR EQUATES TO 38 INCHES LONG
   - 7.2. MANCHETTE LENGTH OF 36 INCHES INTO SOIL, 8.5 INCHES THRU CONCRETE PIPE SECTION, 5.5 INCHES INTERIOR EQUATES TO 50 INCHES LONG
8. UPON COMPLETION OF THE MANCHETTES, DROP PLUNGING ROD DOWN MANCHETTES TO ENSURE NO DEBRIS HAS FILLED TUBE IF GROUNDWATER CONDITIONS EXIST
9. USE FLUSHING WAND TO CLEAN MANCHETTE IF FILLED WITH SOIL DEBRIS
10. TUBES FILLED WITH SOIL PARTICLES, DRILL DEBRIS, OR CHEMICAL GROUT SHALL BE FLUSHED WITH WATER TO CLEAN PRIOR TO MICROFINE CEMENT GROUTING INJECTION
11. KNOCK OF STEEL TIP ON SOLID MANCHETTES ONLY
12. INSTALL FERRULE/BALL-VALVE HARDWARE CONSISTS OF CAM-LOCK INJECTION HEAD, BALL-VALVE, AND FERRULE FITTING ASSEMBLY
13. PRE-INJECT OR FLUSH MANCHETTE WITH FRESH WATER (1 TO 2 GALLONS) TO A PRESSURE OF 25 psig TO ENSURE GROUT ACCEPTANCE AND INTERIOR LEAKAGE DOES NO OCCUR

MOCK-UP FOR CEMENTITIOUS GROUT TESTING

1. MOCK-UP TEST SECTION:
   - 1.1. TEST TWO (2) PIPE SECTIONS (APPROXIMATELY 14 LINEAL FEET) AS DESCRIBED BELOW BEFORE DRILLING OR GROUTING REMAINDER OF ELLIPTICAL CONCRETE CULVERT PIPE.
   - 1.2. TEST SECTION TO VERIFY IF BEDDING CONDITIONS MEETS A TYPE II CONDITION PER THE AMERICAN PIPE ASSOCIATION, DESIGN MANUAL.
   - 1.3. TEST HOLES BEFORE GROUTING TO VERIFY POTENTIAL SOIL TYPE, THICKNESS AND RELATIVE COMPACTION OF FILL MATERIAL.
   - 1.4. TEST HOLES AFTER GROUTING TO VERIFY THAT GROUT HAS PENETRATED OR FRACTURED SOIL AND MADE IT MORE COMPACT.
   - 1.5. TEST HOLES SHOULD VERIFY THAT HAUNCH SOILS ARE MORE COMPACT THAN SOIL AT THE INVERT (6 O'CLOCK POSITION).
   - 1.6. TEST TO VERIFY GROUT TYPE, MIX RATIO AND QUANTITY OF GROUT PUMP TO INCREASE HAUNCH COMPACTION, HOWEVER NOTE THAT INVERT AREA TO BE LESS COMPACT THEN HAUNCH AREAS.
   - 1.7. TEST ALL 8 HOLES BEFORE GROUTING.
   - 1.8. TEST 6 NEW HOLES AFTER GROUTING.
   - 1.9. TEST WITH STATIC CONE PENETROMETER TO VERIFY IT ADEQUATELY TESTS FOR SOIL RESISTANCE.
   - 1.10. TEST IN THE PRESENCE OF A QUALIFIED ENGINEER.
   - 1.11. QUALIFIED ENGINEER TO APPROVE GROUTING OF MOCK-UP TEST SECTION HAS MET ABOVE REQUIREMENTS, BEFORE GROUTING REMAINDER CULVERT PIPES.
   - 1.12. QUALIFIED ENGINEER TO SET TESTING REQUIREMENTS FOR REMAINDER OF PIPE TO BE GROUTED. AS A MINIMUM EACH PIPE MUST HAVE 1 TEST HOLE IN THE HAUNCH AND 1 TEST HOLE AT THE 6 O'CLOCK FLOOR POSITION FOR EVERY OTHER PIPE.
   - 1.13. SEE SHEET 6C FOR GROUT QUANTITIES AND PRESSURE.



4 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION
SECTION, TESTING AND PRESCRIBED GROUT QUANTITIES

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RAYMOND ROAD CULVERT PIPE RESTORATION

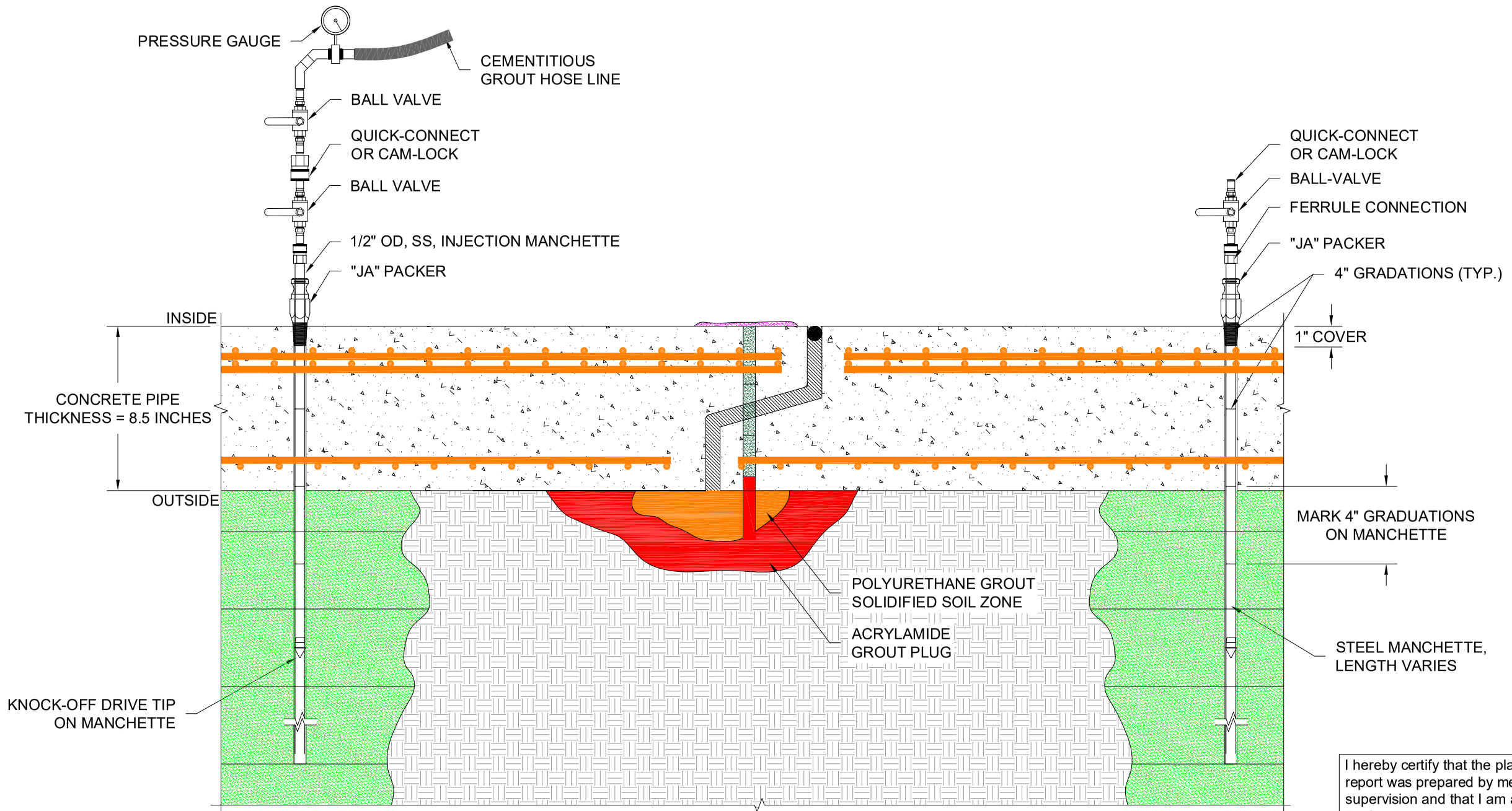
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SHEET: 4C

1. SETUP COLLOIDAL MIXER IN HEATED ENCLOSURE
2. PLACE GRADATIONS AT 3" AND 4" O.C. ON INJECTION MANCHETTE AND SHOW ON SHEET 4C
3. PUSH INJECTION MANCHETTE (24" to 36") INCHES INTO THE UNDERLYING SOIL, AS SHOWN ON PAGES 4C.
4. REMOVE TIP AT END OF MANCHETTE BY RODDING.
5. ATTACH CEMENTITIOUS INJECTION HEAD TO MANCHETTE.
6. MIXING CEMENTITIOUS GROUT:
   - 6.1. FOLLOW MANUFACTURER'S INSTRUCTIONS FOR SETUP OF COLLOIDAL MIXER
   - 6.2. THE FOLLOWING INSTRUCTIONS SHALL BE INSTITUTED FOR CEMENTITIOUS GROUT FORMULATION:
     - 6.2.1. PROVIDE A WATER-TO-CEMENTITIOUS RATIO OF 0.6 BY WEIGHT
     - 6.2.2. PROVIDE 3.2 GALLONS OF WATER PER 44-POUND BAG OF MICRO/ULTRA-FINE CEMENT
     - 6.2.3. ADD SUPERPLASTICIZER PER MANUFACTURER'S RECOMMENDATIONS
     - 6.2.4. THE YIELD OF THESE SPECIFICATIONS SHOULD APPROXIMATE 5.4 GALLONS OF PUMPABLE CEMENTITIOUS GROUT PER BAG
     - 6.2.5. USE COLD WATER IN LIEU OF WARM WATER FOR MIXING TO IMPROVE FLOWABILITY
     - 6.2.6. DO NOT ADD FLYASH, LINE OR SILICA POWDER TO MIX
   - 6.3. SUFFICIENTLY MIX MICRO/ULTRA-FINE CEMENT AND WATER TO A "CREAM-LIKE" CONSISTENCY WITHOUT LUMPS
   - 6.4. INJECT MICRO/ULTRA-FINE CEMENT GROUT AS FOLLOWS:
     - 6.4.1. MIX AND PROPORATION MICRO/ULTRA-FINE CEMENT GROUT IN A COLLOIDAL MIXER PER MANUFACTURER'S INSTRUCTIONS,
     - 6.4.2. DISBURSE CEMENTITIOUS GROUT INTO GROUT PUMP,
     - 6.4.3. PUMP CEMENTITIOUS GROUT AT A RATE OF 1/2 GALLON PER MINUTE INTO MANCHETTE, DO NOT EXCEED THIS RATE OF INJECTION. INJECTION RATES IN EXCESS OF 1/2 GALLON PER MINUTE POTENTIALLY WILL INDUCE FRACKING PLANES IN SOIL GROUT ZONE
     - 6.4.4. IF INJECTION GROUT RATE INCREASES TO 1/4 GALLON PER MINUTE, AT MAXIMUM ALLOWABLE GROUT PRESSURE, FOR FIVE (5) CONSECUTIVE MINUTES, REFUSAL CRITERIA ARE MET AND MOVE TO NEXT MANCHETTE



5 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION
INJECTION PROCEDURE

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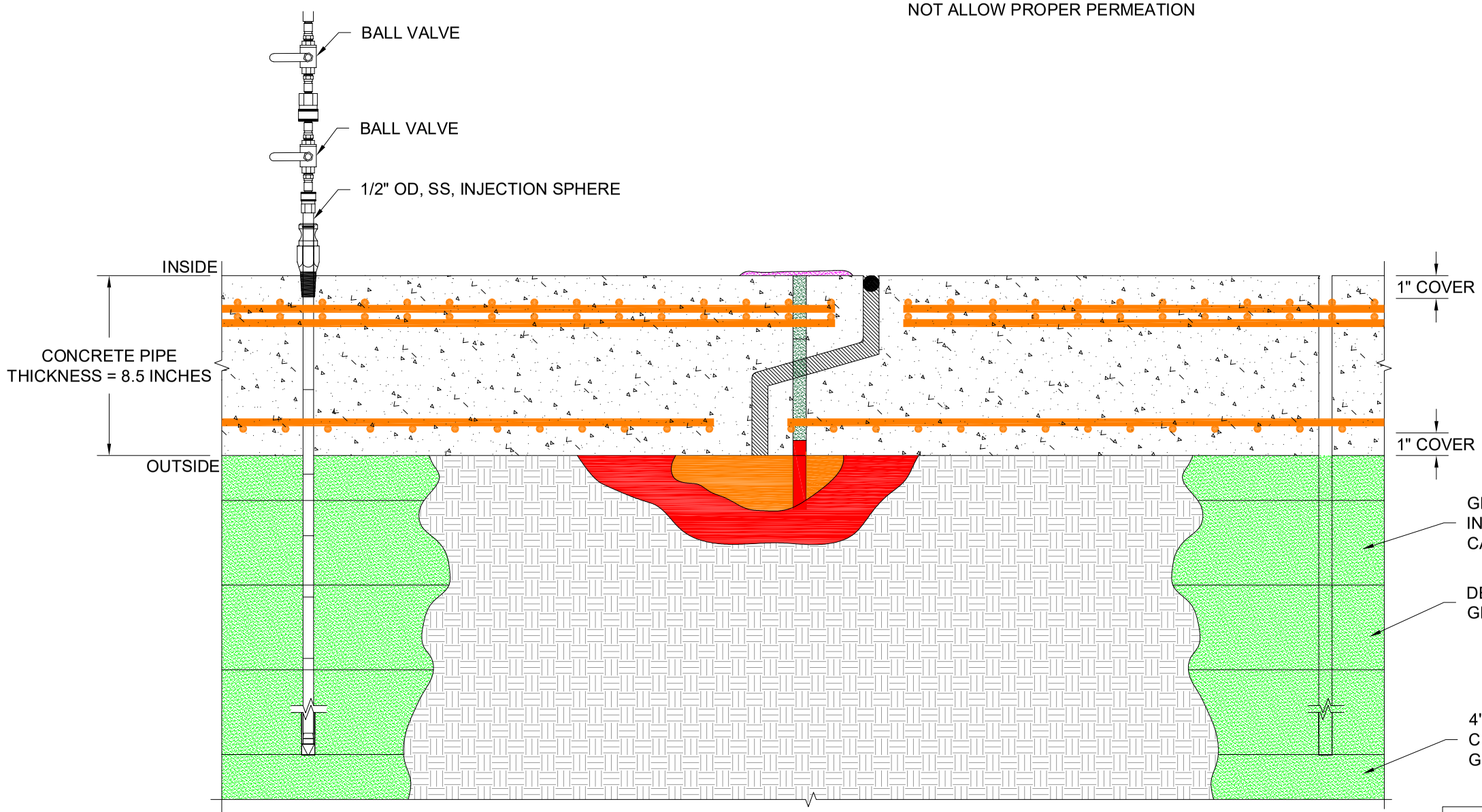
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 5C

1. WHEN SOIL GROUTING LAST LIFT OF BOTH 38" AND 50" MANCHETTES (i.e. WITHIN THREE (3) INCHES OF ELLIPTICAL CONCRETE PIPE EXTERIOR), PROCEED AS FOLLOWS:
   - 1.1. PUMP THE DESIGNATED 2-GALLON PER 3" LIFT AT A RATE OF 1/2 GALLON PER MINUTE
   - 1.2. NOTE THE PUMPING GROUT PRESSURE, IF IT DOES NOT EXCEED 30 psig, GROUTING ON THIS LIFT TILL REFUSAL IS MET
   - 1.3. NOTE THAT EXCESSIVE SOIL VOIDS, OR LOW COMPACTION MATERIAL EXISTS AND IS PRESENT, IN THESE AREAS; DOCUMENT ADDITIONAL GROUT INJECTED IN MANCHETTE
2. INJECT CEMENTITIOUS GROUT INTO EACH MANCHETTE AS FOLLOWS AT SPACINGS SHOWN ON DRAWINGS,
   - 2.1. 38" MANCHETTE SHALL BE GROUTED AS FOLLOWS:
     - 2.1.1. INJECT 8-GALLONS PER FOOT FOR 2 FEET:
       - 2.1.1.1. 2-GALLONS PER 4" LIFTS FOR 12 INCHES, AND
       - 2.1.1.2. 2-GALLONS PER 3" LIFTS FOR 12 INCHES,
       - 2.1.1.3. WHICH EQUATES TO 16 GALLONS PER MANCHETTE
   - 2.2. 50" MANCHETTE SHALL BE GROUTED AS FOLLOWS:
     - 2.2.1. INJECT 8-GALLONS PER FOOT FOR 3 FEET:
       - 2.2.1.1. 2-GALLONS PER 4" LIFTS FOR 12 INCHES, AND
       - 2.2.1.2. 2-GALLONS PER 3" LIFTS FOR 24 INCHES,
       - 2.2.1.3. WHICH EQUATES TO 24 GALLONS PER MANCHETTE
3. MICRO/ULTRA-FINE CEMENT GROUTING PROCEDURES:
   - 3.1. MICRO/ULTRA-FINE CEMENT GROUT INJECTION PRESSURE VARIATION SHALL BE BETWEEN (10 to 30) psig, GROUT PRESSURE SHALL NOT EXCEED 40 psig
     - 3.1.1. PERFORM CEMENTITIOUS GROUTING VIA BOTTOM-UP PROCEDURES, THE FIRST LIFT IS FARTHEST FROM THE CONCRETE PIPE EXTERIOR.
     - 3.1.2. GROUTING WITH 38" LONG MANCHETTES SHALL BE DONE WITH EIGHT (8) 3" LIFTS,
       - 3.1.2.1. THE LAST LIFT (No. 8, CLOSES TO PIPE) SHALL CONTINUE UNTIL GROUT PRESSURE EXCEEDS 30 psig TO ENSURE ANY BACKFILL VOIDS IN HAUNCH AREAS ARE FILLED
     - 3.1.3. GROUTING WITH 50" LONG MANCHETTES SHALL BE DONE WITH TWELVE (12) 3" LIFTS,
       - 3.1.3.1. THE LAST LIFT (No. 12, CLOSEST TO PIPE) SHALL CONTINUE UNTIL GROUT PRESSURE EXCEEDS 30 psig TO ENSURE ANY BACKFILL VOIDS IN HAUNCH AREAS ARE FILLED
   - 3.2. PUMP MICRO/ULTRA-FINE CEMENT GROUT AT A RATE NOT TO EXCEED 1/2 GALLON PER MINUTE,
     - 3.2.1. NOTE - PUMPING IN-EXCESS-OF 1/2 GALLON PER MINUTE WILL FRACK THE SOIL LAYERS AND NOT ALLOW PROPER PERMEATION



6 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION
INJECTION PROCEDURE

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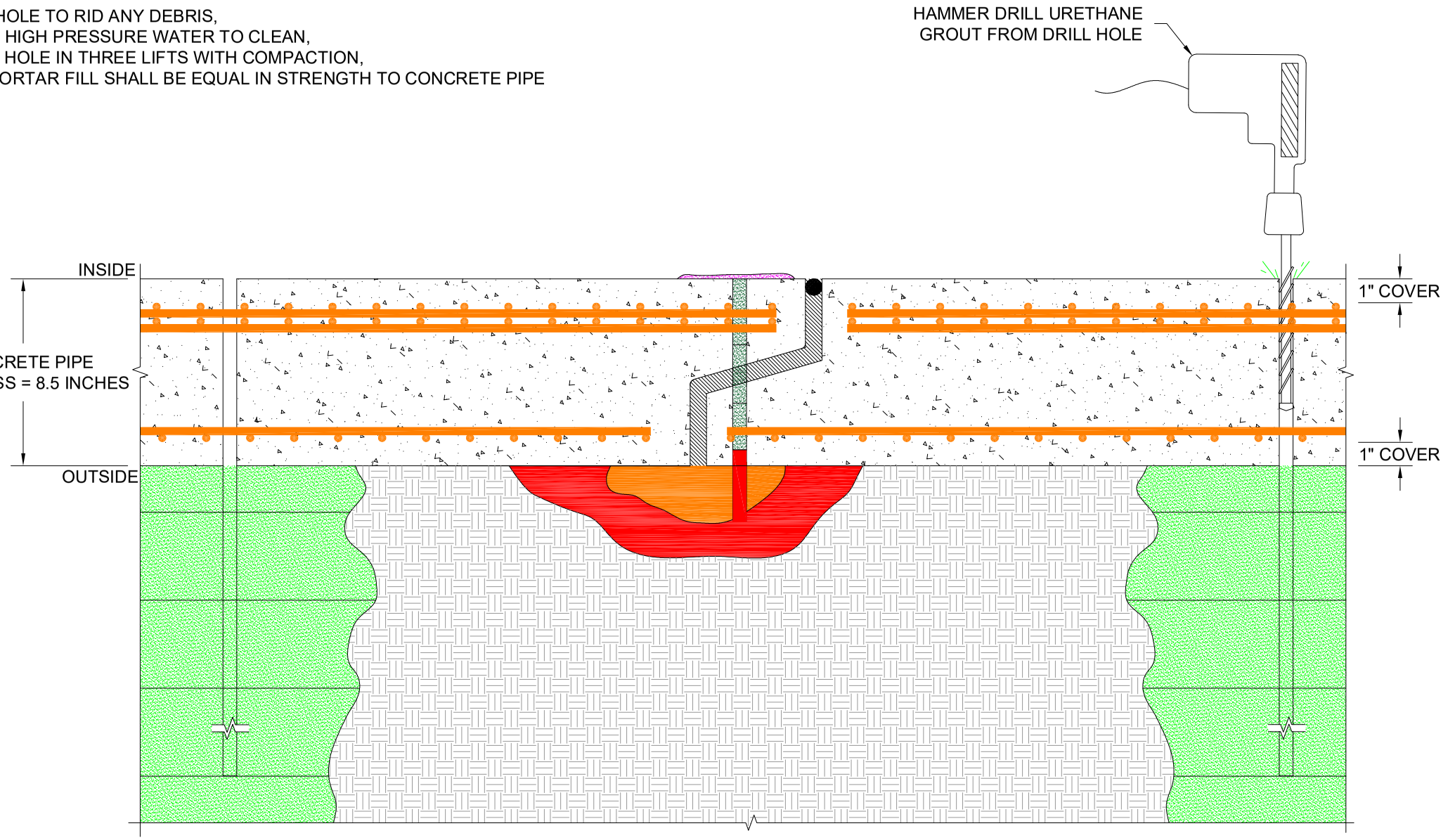
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 6C

1. AFTER REMOVAL OF MANCHETTE FROM "JA" PACKER, PLACE CAM-LOCK CAP ON PACKER, OR AN OPTIONAL PROCEDURE IS TO REMOVE PACKER AND PLUG WITH WOOD DOWEL
2. AFTER 3-5 DAYS OF CEMENTITIOUS GROUT CURES, DRILL TWO (2) 3/4" Ø HOLES AS SHOWN ON PLANS TO TEST GROUTED SOIL ZONE
   - 2.1. PERFORM STATIC CONE PENETROMETER AT 12" OR 18" DEPTHS
   - 2.2. GOAL TO ACHIEVE 25% INCREASE IN SOIL STRENGTH FROM CEMENTITIOUS GROUTING
   - 2.3. IF SOIL STRENGTH IS NOT ACHIEVED, CONTACT EDR FOR MODIFIED GROUTING PROCEDURES
3. MANCHETTE DISMANTLING:
   - 3.1. ALLOW GROUT TO GEL/SET/CURE/HARDEN AND THEN REMOVE BALL-VALVE "JA" HARDWARE,
   - 3.2. RE-DRILL GROUT HOLE TO RID ANY DEBRIS,
   - 3.3. FLUSH HOLE WITH HIGH PRESSURE WATER TO CLEAN,
   - 3.4. DRY-PACK GROUT HOLE IN THREE LIFTS WITH COMPACTION,
   - 3.5. CEMENT BASED MORTAR FILL SHALL BE EQUAL IN STRENGTH TO CONCRETE PIPE



7 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION
RE-DRILL GROUT FROM DRIL HOLE

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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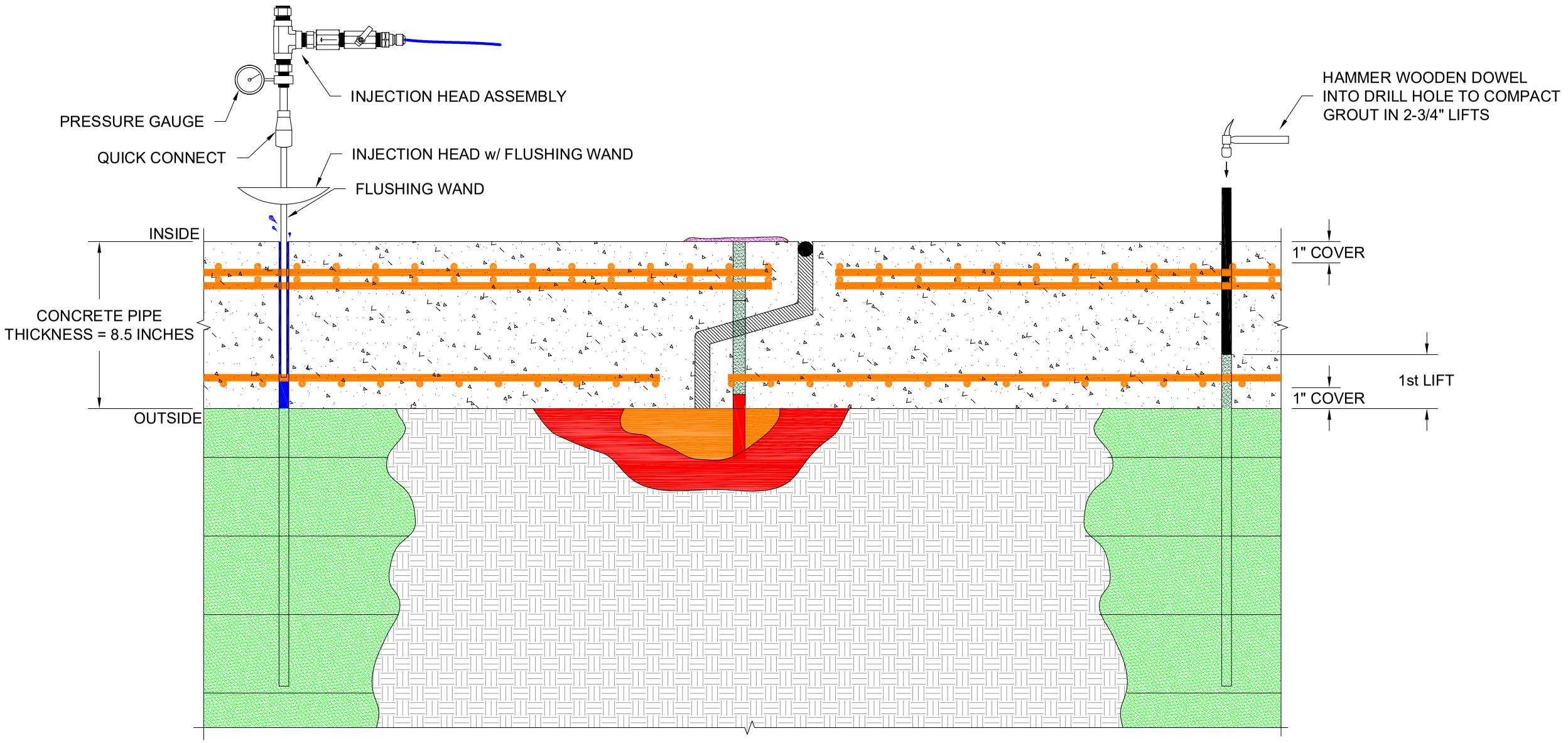
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 7C

1. FLUSH DRILL / CORE HOLE AFTER INITIAL SET.
2. USE ROD TO COMPACT GROUT IN 3" LIFTS IN EACH DRILL / CORE HOLE.



8 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION
DRILL HOLE PREPERATION

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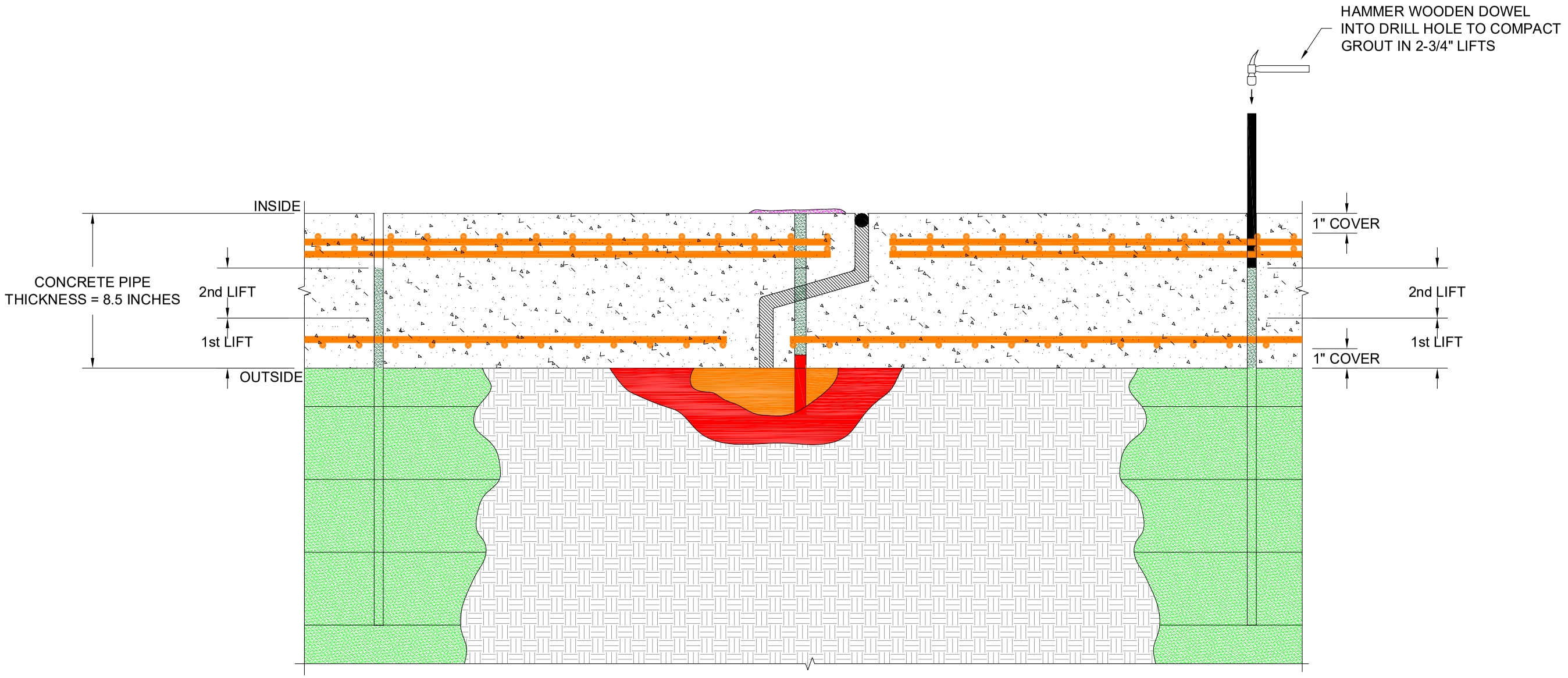
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 8C



9 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION

CEMENTITIOUS MORTAR TO FILL DRILL HOLES

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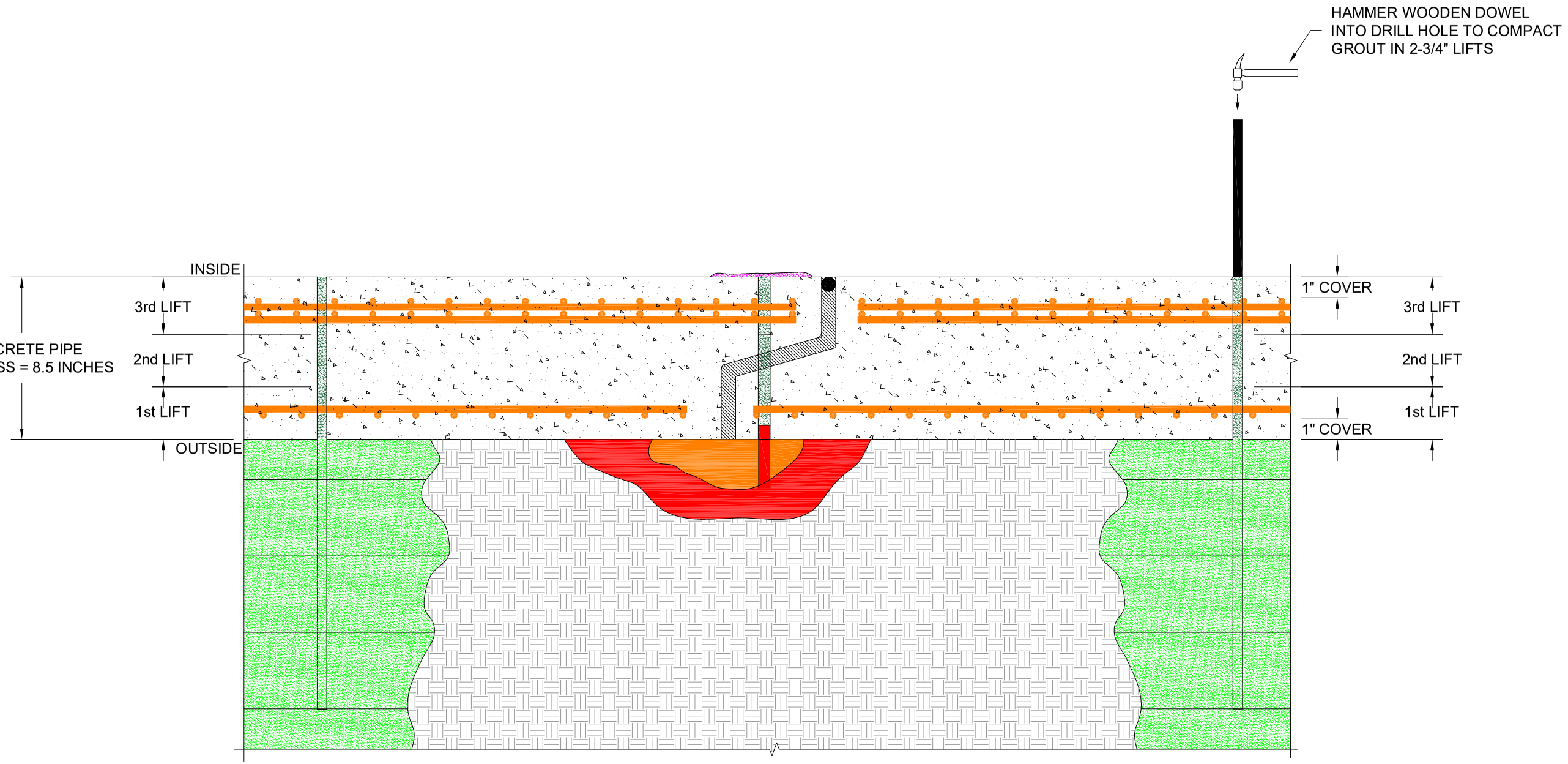
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 9C



10 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION
COMPLETED DRILL HOLE RESTORATION

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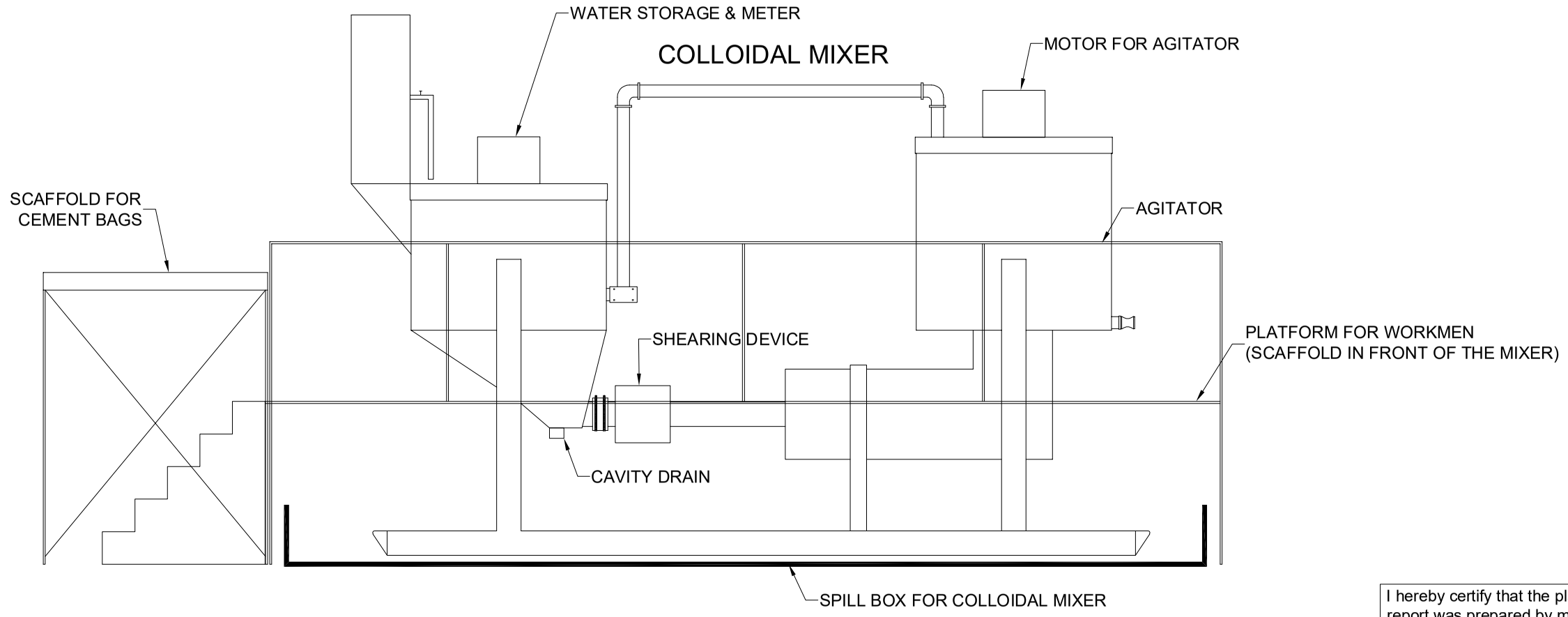
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 10C

MIXING WITH THE COLLOIDAL MIXER AND PUMPING WITH THE ROTOR -STATOR PUMP:

ENSURE COLLOIDAL MIXER IS PREPARED:

1. CHOOSE A LOCATION FOR THE COLLOIDAL MIXER WHERE FORKLIFT ACCESS IS APPROPRIATE TO MOVE PALLETS OF CEMENT BAGS INTO POSITION.
2. PLACE SPILL BOX / PAD UNDER COLLOIDAL MIXER AND ROTOR-STATOR PUMP. SOME CONTRACTORS PLACE LEVEL PAD UNDER SCAFFOLD AS WELL.
3. LEVEL MIXER WITH WOOD BLOCKS AND / OR METAL SHIMS ON SPILL PAD. IT IS RECOMMENDED TO ELEVATE THE COLLOIDAL MIXER HIGH ENOUGH TO ENSURE THE DISCHARGE PIPE ON THE AGITATOR TANK IS ABOUT 4 INCHES HIGHER THAN THE ROTOR-STATOR CAVITY BOX.
4. MOST CONTRACTORS WANT TO BUILD A SCAFFOLD ABOUT TWO FEET HIGH TO FACILITATE EASE OF WORKING. SOME CONTRACTORS BUILD A SCAFFOLD 4 FEET HIGH ON THE COLLOIDAL MIXER END NEAR THE SHEAR TANK, TO ACCOMMODATE ACCESS TO THE CEMENT BAGS.
5. SPRAY FORM-RELEASE AGENT, OIL, OR SIMILAR ON COLLOIDAL MIXER AND ROTOR-STATOR PUMP TO AID IN CLEANUP.
6. FILL OIL RESERVOIR BASIN FOR AIR MOTORS WITH MARVEL AIR TOOL OIL OR EQUAL.
7. GREASE ALL ZERK FITTINGS (4 THUS ON MACHINE) AND FILL GREASE RESERVOIR.
8. ENSURE DRAIN CAP PLACED ON BOTTOM OF SHEARING / MIXING TANK IS SECURE.
9. ENSURE STRAINER IS CLEAN BETWEEN SHEARING / MIXING TANK AND AGITATION TANK.
10. HOOK UP COMPRESSED AIR FITTING TO MIXER.
11. ADD 5-GAL. OF WATER TO SYSTEM.
12. TURN ON SYSTEM, MOVE LEVELS BACK AND FORTH TO UNDERSTAND OPERATIONAL PROTOCOL. YOU WILL NOT DAMAGE ANYTHING BY LEVER OPERATION AS-LONG-AS JUST WATER IS IN THE SYSTEM.
    - 12.1. LEVER FORWARD - DISCHARGE TO AGITATION TANK.
    - 12.2. LEVER BACKWARD - RECIRCULATING GROUT THROUGH HIGH SHEAR MIXER.
    - 12.3. NOTE THE BALL VALVE LEVER TO START AND STOP THE AGITATION TANK.
13. NOTE THAT THE OIL LIBERATOR SHOULD BE SUPPLYING AIR WITH OIL TO THE TWO AIR MOTORS ON THE MACHINE. CHECK OIL LEVELS EVERY 4 HOURS.
14. THEN DISCHARGE THE WATER TO THE AGITATOR TANK.
15. TURN ON AGITATOR BLADE IN THE TANK.
16. THEN DISCHARGE WATER OUT OF THE TANK INTO THE ROTOR STATOR CAVITY BOX.
17. PUMP WATER TO THE END OF THE HOSE.
18. ONE CAN RE-USE DISCHARGE WATER IF IT'S CLEAN AND CONTAINS NO DEBRIS.



11 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION
COLLOIDAL MIXER SET-UP & OPERATION

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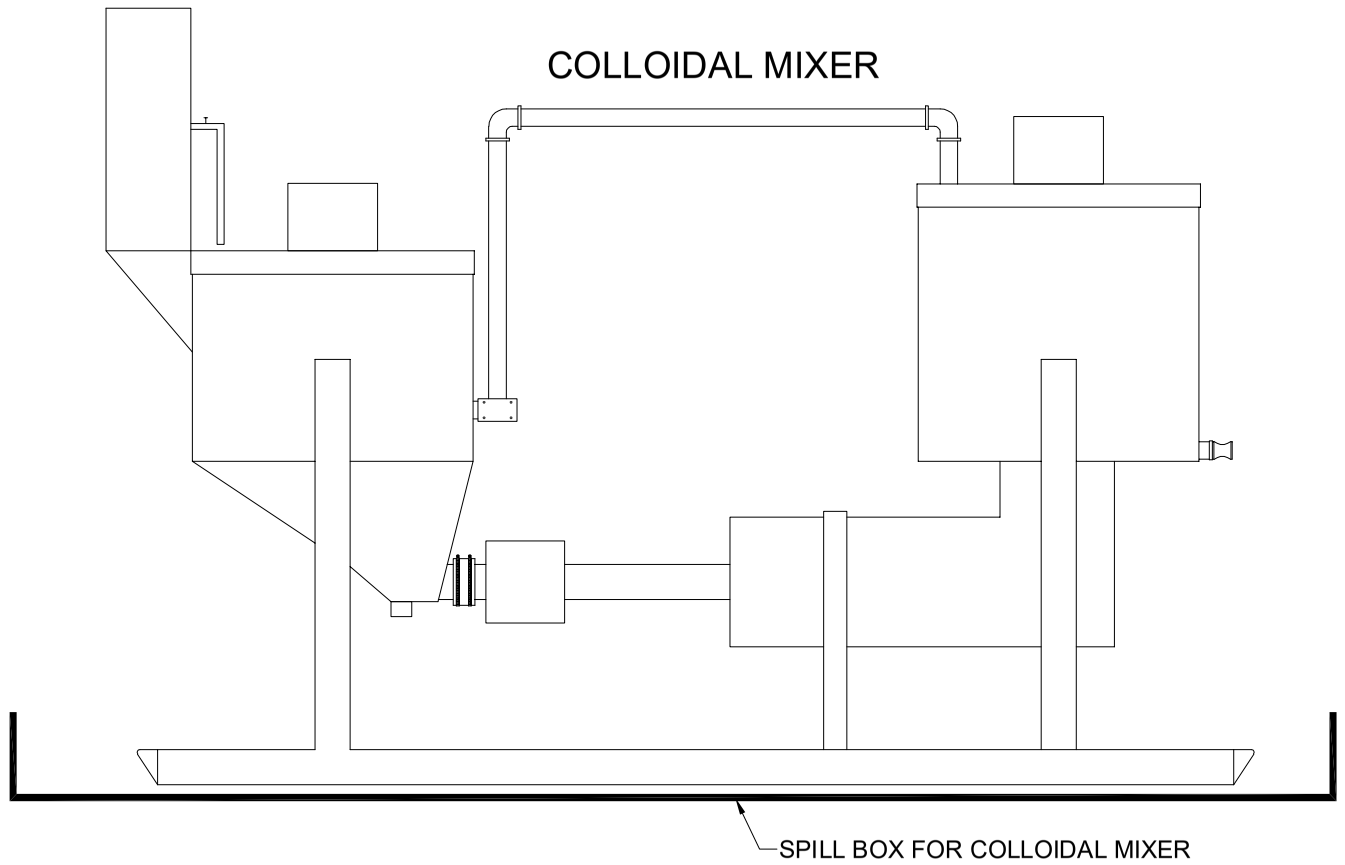
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RAYMOND ROAD CULVERT PIPE RESTORATION

1. ADD 12 GAL. OF POTABLE WATER TO COLLOIDAL MIXER,
2. ADD 7 oz. UNIT OF SUPERPLASTIZER,
3. ADD 44 POUND BAG OF ULTRAFINE CEMENT,
4. CIRCULATE WATER THRU HIGH SHEAR DEVICE,
5. SLOWLY ADD 2nd BAG OF MICROFINE CEMENT,
6. SLOWLY ADD 3rd BAG OF MICROFINE CEMENT,
7. SLOWLY ADD 4th BAG OF MICROFINE CEMENT,
8. ADD 1 GAL. OF WATER
9. YOU SHOULD HAVE APPOXIMATELY 27 GALLONS OF FLOWABLE GROUT.
10. ENSURE ALL LOOSE CEMENT POWDER IS IN MIX, CAREFULLY SCRAPE TOP / SIDES OF SHEAR TANK.
11. WARM WATER WILL INCREASE DEMAND FOR ADDITIONAL WATER.
12. COLD WATER WILL DECREASE DEMAND FOR ADDITIONAL WATER.
13. ALLOW TO RE-CIRCULATE FOR THREE MINUTES OR MORE.
14. DISCHARGE GROUT TO AGITATION TANK THRU STRAINER, MONITOR STRAINER FOR LUMPS.
15. LUMPS IN GROUT INDICATES LONGER MIXING TIME REQUIRED THRU HIGH SHEAR DEVICE.
16. LUMPS CAN BE DISPOSED IN TRASH.
17. REPEAT PROCESS BASED ON DEMAND.
18. NOTE - ONCE EVERY TWO HOURS, USE 4000 PSI WATER BLASTER TO FLUSH OUT BOTTOM OF HIGH SHEAR MIXING TANK AND CAVITY BOX OF ROTOR-STATOR PUMP, THE FLUSH WATER CAN BE RECYCLED AND USED FOR MIXING.
19. NOTE - ONCE EVERY FOUR HOURS, RUN SPONGES THROUGH HOSES FOR FLUSHING, THIS WILL HELP AVOID PLUGGING.

CLEAN-UP OF COLLOIDAL MIXER:

1. FLUSH COPIOUS AMOUNTS OF WATER THRU MIXING TANK.
2. DISCHARGE TO AGITATION TANK AND CIRCULATE.
3. USE 4000 PSI POWER WASHER (WATER-BLASTER) TO CLEAN MIXING TANK THOROUGHLY.
4. POWER WASH ALL RESIDUE ON INSIDE AND OUTSIDE OF MIXING TANK.
5. DISCHARGE TO AGITATION TANK.
6. POWER WASH STRAINER.
7. DISCHARGE AGITATOR TANK WATER TO PLASTIC STORAGE TANK OR DRUMS.
8. POWER WASH INSIDE AND OUTSIDE OF AGITATOR TANK.
9. DISCHARGE AGITATOR TANK WATER TO PLASTIC STORAGE TANK OR DRUMS.
10. DISCHARGE WATER FROM STORAGE TANK OR DRUMS. THEY CAN BE USED FOR MIXING WATER THE SAME OR FOLLOWING DAY.
11. TAKE CAP OFF OF THE BOTTOM OF THE MIXING TANK, ENSURE IT IS CLEAN.
12. SPRAY TANK WITH FORM RELEASE AGENT.



12 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION

COLLOIDAL SET-UP & OPERATION

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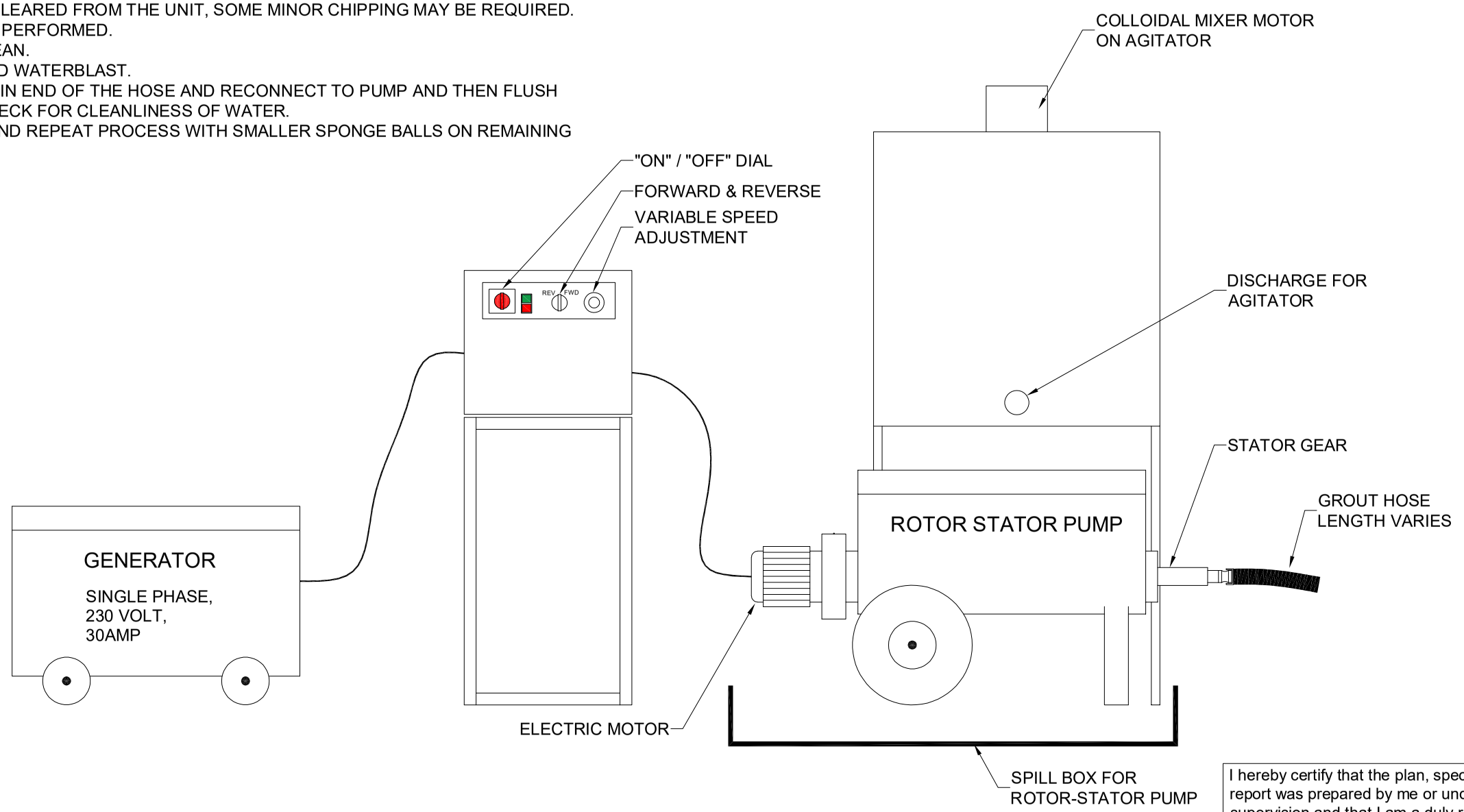
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 12C

1. ROTOR-STATOR PUMP OPERATES AT 230 VOLT, 30 AMP., SINGLE PHASE, ELECTRIC CIRCUIT.
2. COORDINATE WITH PLANT PERSONNEL TO ACCOMMODATE SUCH A HOOK-UP.
3. THERE SHOULD BE 100 LINEAL FEET OF ELECTRICAL LINE SUPPLIED BY STRUCTURAL TECHNOLOGIES.
4. CHECK TO ENSURE THE PLUG ENDS WILL MATCH THE SERVICE.
5. ASSEMBLE THE ROTOR-STATOR PUMP BOX CAVITY TO THE ELECTRICAL MOTOR AND ROTOR-STATOR PUMP.
   - 5.1. THIS IS DONE WITH THE WEDGES.
   - 5.2. ENSURE THE AUGER IS PROPERLY POSITIONED INTO PLACE AT EACH END.
   - 5.3. GREASE THE XERK FITTINGS ON THE CAVITY BOX TILL GREASE EXTRUDES FROM SIDES.
6. SITUATE THE ELECTRICAL CONTROL BOX FOR ROTOR-STATOR PUMP A FEW FEET (5 - 10) AWAY FROM THE PUMP.
7. PLUG IN THE PUMP MOTOR TO THE CONTROL BOX, PLUS IN SERVICE TO THE CONTROL BOX.
8. TURN ON DIAL TO THE RIGHT, PRESS THE GREEN BUTTON TO START.
9. REGULATE SPEED OF AUGER.
10. HOOK UP HOSES FROM ROTOR-STATOR PUMP TO MANCHETTES.

CLEAN-UP OF ROTOR-STATOR PUMP:

1. ENSURE ALL HARDENED GROUT IS CLEARED FROM THE UNIT, SOME MINOR CHIPPING MAY BE REQUIRED.
2. BE SURE UNIT IS OFF IF CHIPPING IS PERFORMED.
3. FLUSH WITH WATER TILL UNIT IS CLEAN.
4. DISCONNECT CAM-LOCK FITTING AND WATERBLAST.
5. PLACE APPROPRIATE SPONGE BALL IN END OF THE HOSE AND RECONNECT TO PUMP AND THEN FLUSH BALL THROUGH THE LINE TWICE, CHECK FOR CLEANLINESS OF WATER.
6. DISCONNECT THE CLEANED HOSE AND REPEAT PROCESS WITH SMALLER SPONGE BALLS ON REMAINING HOSE IF USED.



13 CEMENTITIOUS GROUT, HAUNCH AREA INJECTION

ROTOR STATOR PUMP SET-UP & OPERATION

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 13C

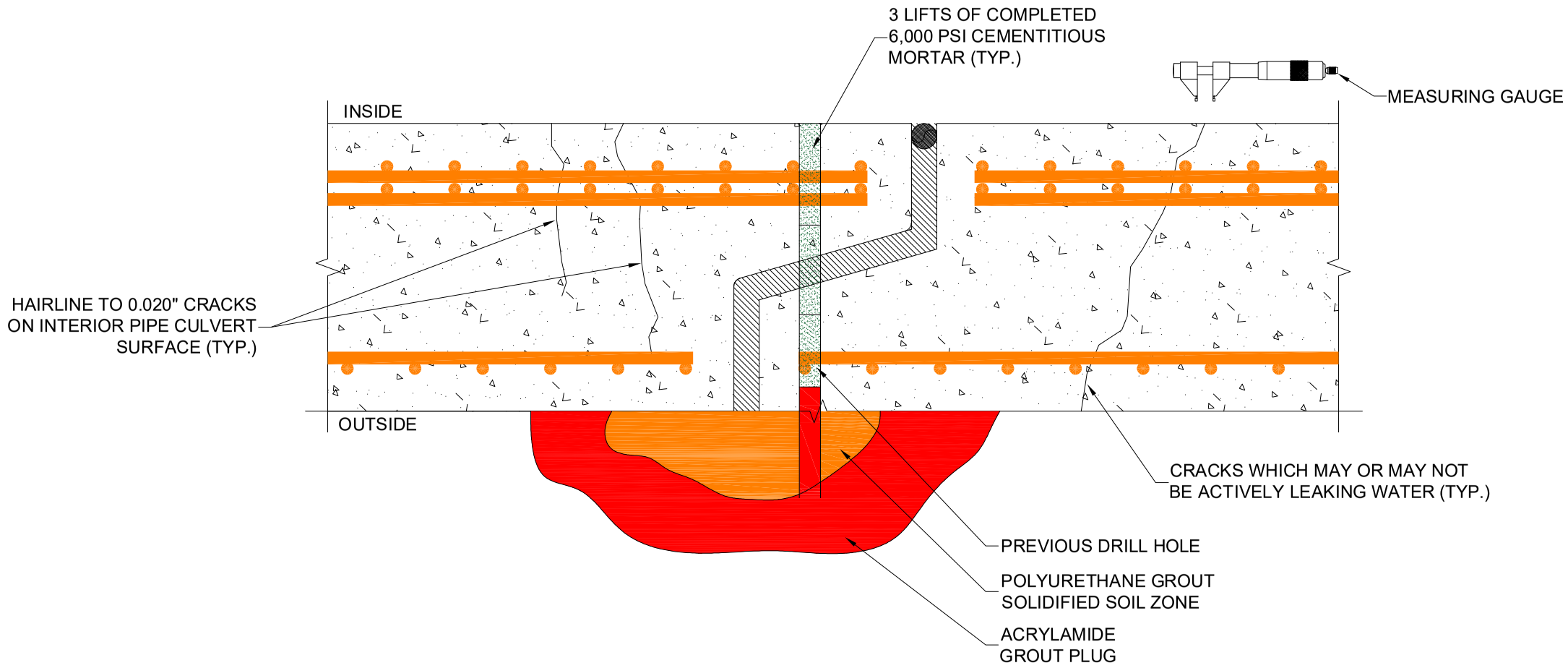
GENERAL CONDITIONS:

1. COORDINATE SAFETY PLAN TO INCLUDE MANAGEMENT OF MANCHETTE TOPS TO AVOID TRIP HAZARDS TO TRADESMEN
2. COORDINATE ACCESS/EGREE PLAN IN CASE OF HIGH WATER, EXCESS CARBON DIOXIDE, LACK OF LIGHTING AND/OR OTHER ISSUES THAT MAY REQUIRE UNPLANNED EVACUATION OF CULVERT PIPE
3. COORDINATE WORKING TIMES TO ENSURE STORM WATER DRAINAGE DOES NOT INTERFERE WITH GROUTING OPERATIONS BEYOND MANAGED WATER RE-ROUTING
4. ENSURE PROJECT TEAM IS COORDINATED WITH WEATHER FORECASTS AND CURRENT CONDITIONS
5. ENSURE WATER DIVERSION PLAN IS APPROVED BY OWNER
6. FOLLOW ALL OSHA REQUIREMENTS FOR CONFINED SPACE
7. ENSURE:
   - 7.1. PROPER & ADEQUATE LIGHTING & ELECTRICAL SUPPLY
   - 7.2. PROPER & ADEQUATE FRESH AIR-SUPPLY
   - 7.3. PROPER & ADEQUATE AIR QUALITY MONITORING
   - 7.4. PROPER & ADEQUATE EYE WASH STATIONS ARE SETUP

1. MEASURE WIDTH OF ALL CRACKS:
2. NOTE THE FOLLOWING:
   - 2.1. CRACKS LESS THAN 0.021 INCHES (21 MILS) SHALL BE SURFACE TREATED WITH CRYSTALLINE WATERPROOFING
   - 2.2. CRACKS GREATER THAN 0.021 INCHES AND LESS THAN 0.040 INCHES (40 MILS) SHALL BE INJECTED WITH POLYACRYLATE GROUT
   - 2.3. CRACKS GREATER THAN 0.040 INCHES (40 MILS) SHALL BE INJECTED WITH EPOXY RESIN

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"B" SERIES DRAWINGS	1B-30B	Section 03 64 20 Acrylamide Grout Joint Injection, Soil Solidification	WP-2
"C" SERIES DRAWINGS	1C-13C	Section 03 61 10 Ultra-Fine Cement, Soil Stabilization	SS-3
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"G" SERIES DRAWINGS	1G-4G	Section 07 13 56 Thermoplastic Sheet Strip Seals	WP-7
GENERAL NOTES:			
1. STEEL REINFORCING VARIES AT LOCATIONS IN CULVERT PIPE.			



1 CRYSTALLINE WATERPROOF TREATMENT

HAIRLINE TO 20 MIL CRACKS IN CONCRETE PIPE, EXISTING CONDITIONS

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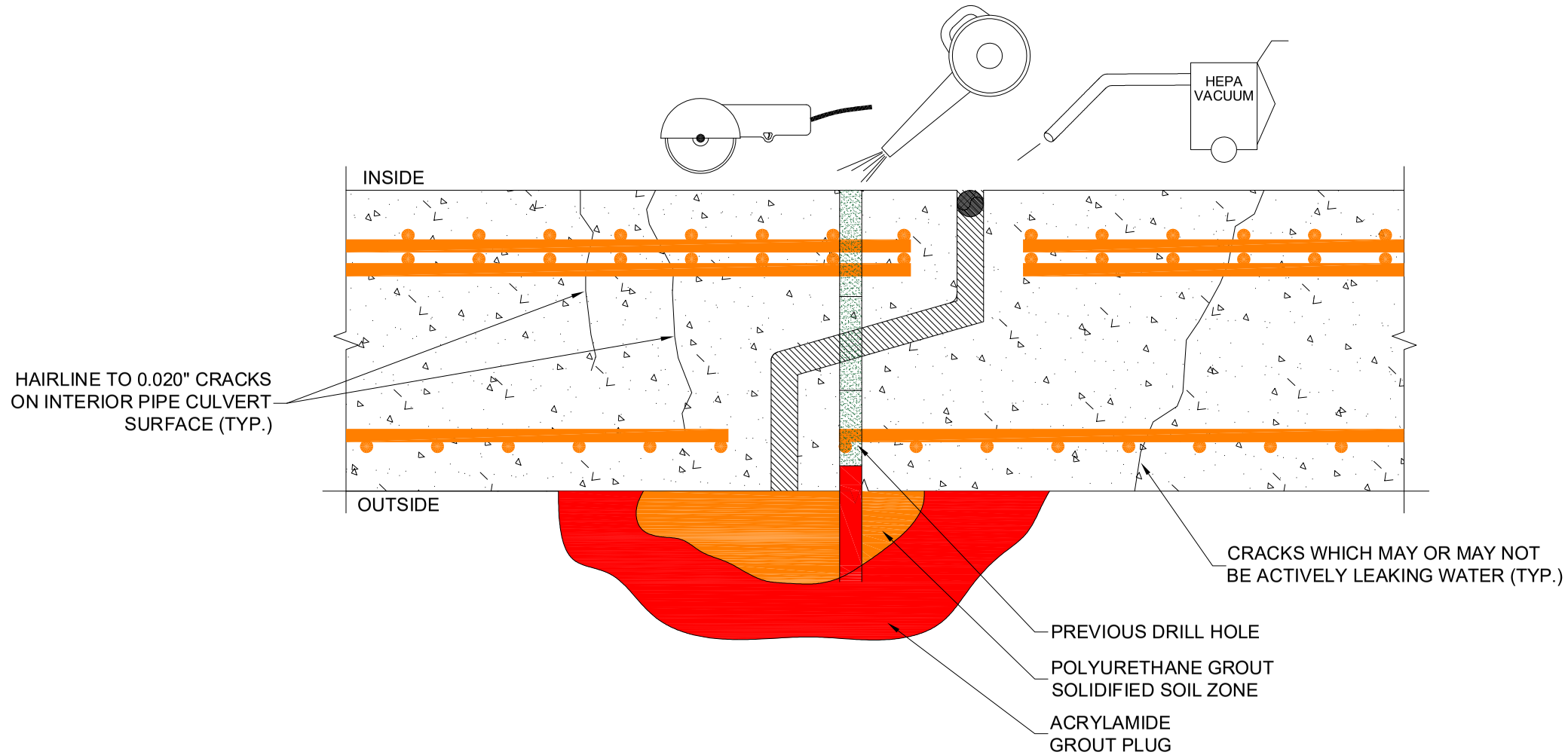
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 1D

1. MEASURE WIDTH OF ALL CRACKS:
2. NOTE THE FOLLOWING:
   - 2.1. CRACKS LESS THAN 0.021 INCHES (21 MILS) SHALL BE SURFACE TREATED WITH CRYSTALLINE WATERPROOFING
   - 2.2. CRACKS GREATER THAN 0.020 INCHES AND LESS THAN 0.040 INCHES (40 MILS) SHALL BE INJECTED WITH POLYACRYLATE GROUT
   - 2.3. CRACKS GREATER THAN 0.040 INCHES (40 MILS) SHALL BE INJECTED WITH EPOXY RESIN



2 CRYSTALLINE WATERPROOF TREATMENT

HAIRLINE TO 20 MIL CRACKS IN CONCRETE PIPE, SURFACE PREPERATION

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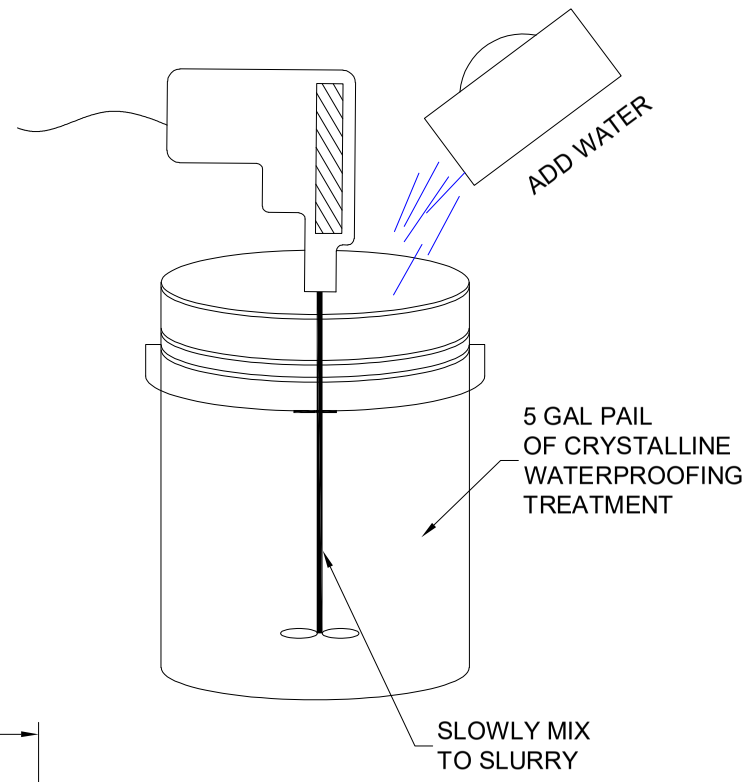
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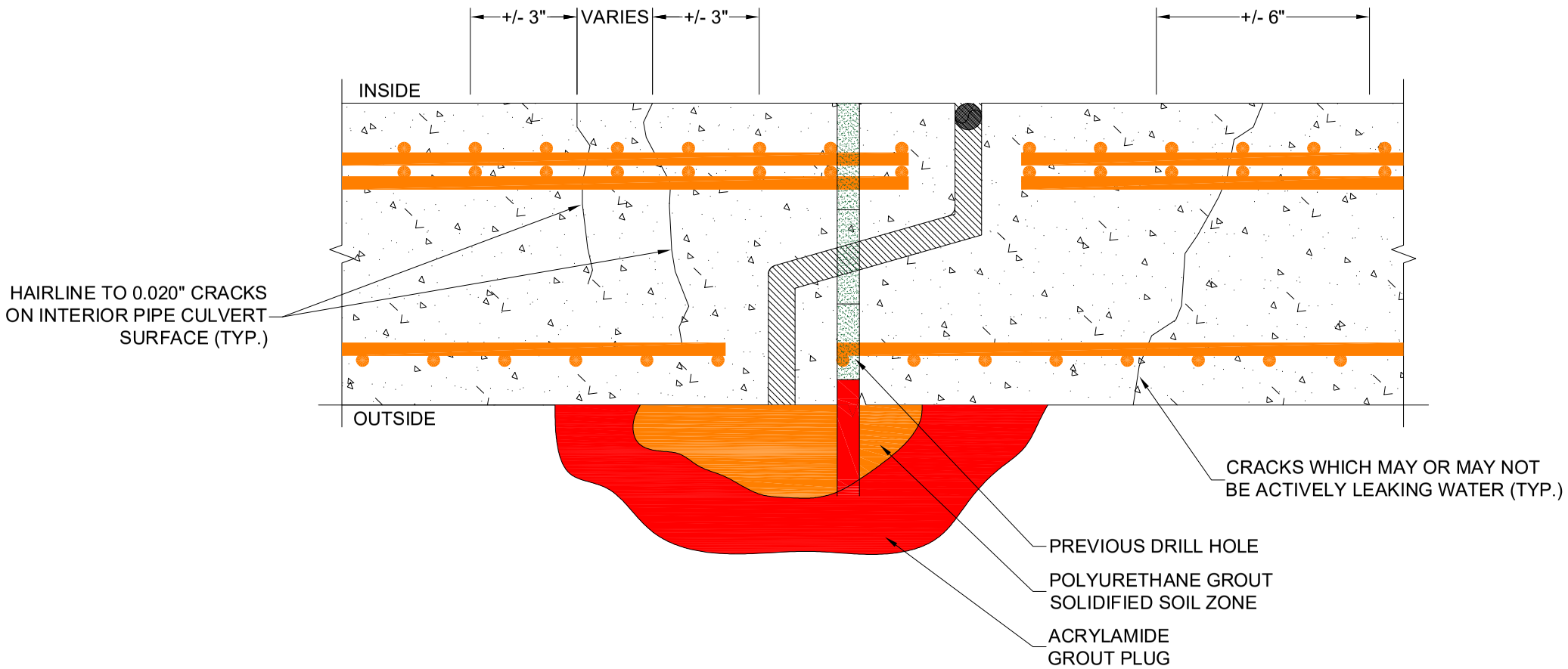
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 2D

1. MIX CRYSTALLINE WATERPROOFING SLURRY PER MANUFACTURER'S DIRECTIONS





3 CRYSTALLINE WATERPROOF TREATMENT

HAIRLINE TO 20 MIL CRACKS IN CONCRETE PIPE, MIXING INSTRUCTIONS

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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1	1/9/2020	REVISIONS	TB

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DRN	TB	1/9/2020
CHK	BA	1/9/2020

JOB NO.

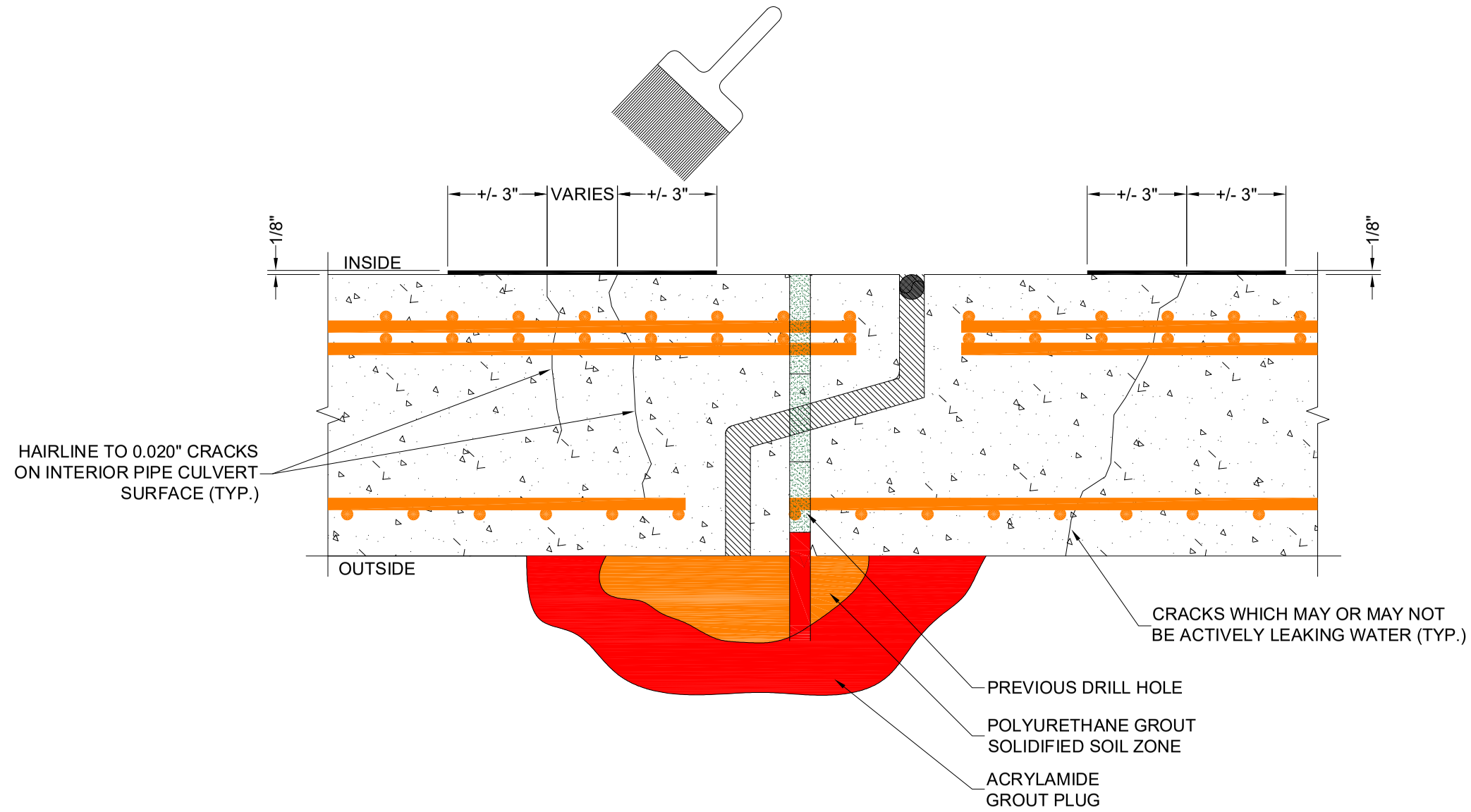
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 3D

1. APPLY 2 SLURRY COATS OF CRYSTALLINE WP APPROXIMATELY 3" ON EACH SIDE OF CRACKS LESS THAN 0.021 INCHES (21 MILS)
2. ALLOW 3 HOURS BETWEEN +/- 1/16" COATS
3. KEEP MOIST FOR 3 DAYS OR SPRAY CURING COMPOUND ON SURFACE



4 CRYSTALLINE WATERPROOF TREATMENT

HAIRLINE TO 20 MIL CRACKS IN CONCRETE PIPE, TREATMENT APPLICATION

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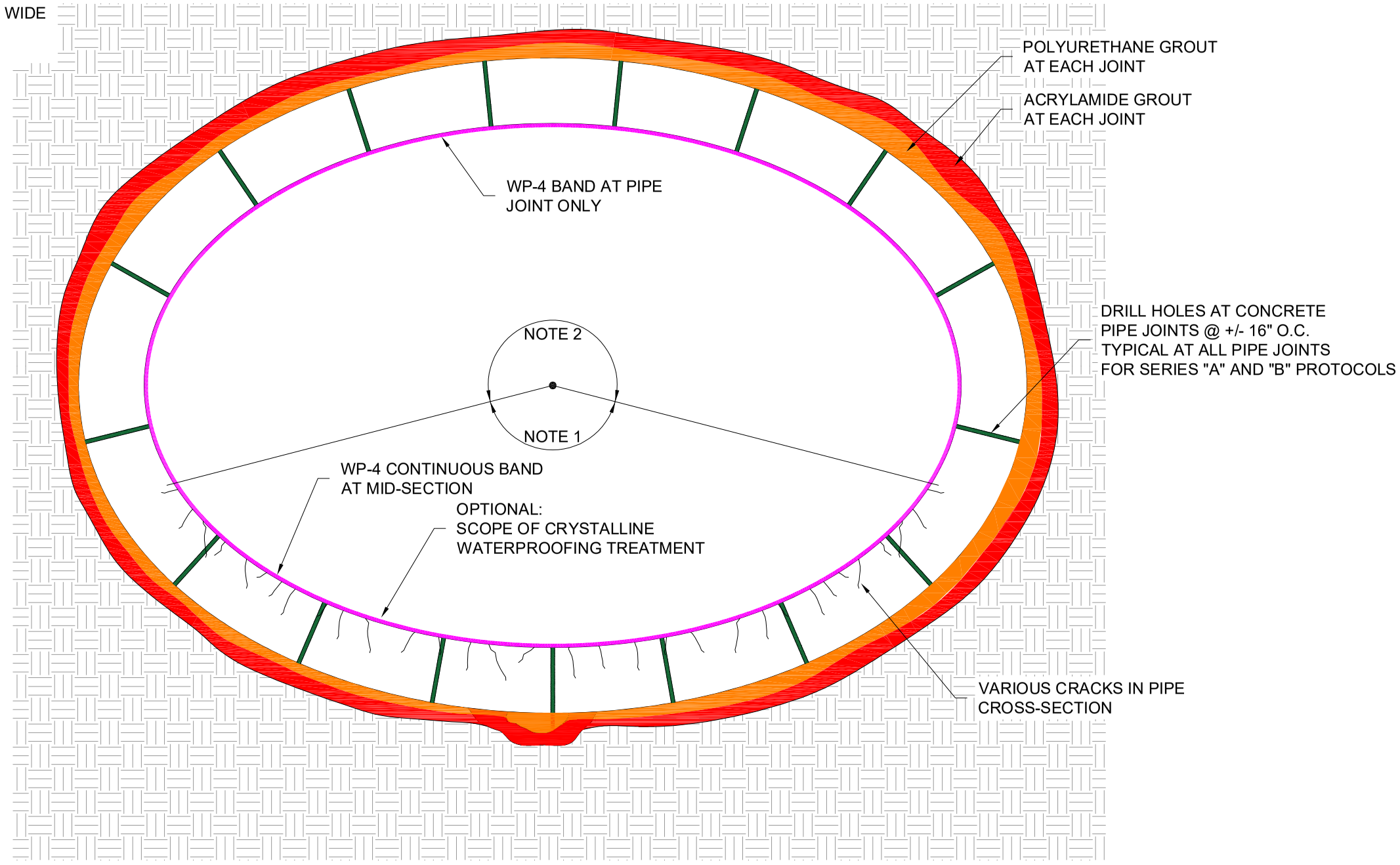
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 4D

NOTE 1: CONTRACTOR OPTION TO TREAT 62" WIDE ZONE AT EACH SIDE OF INVERT WITH WP-4 IN LEIU OF 6"x6" SPOT TREATMENT ALL PENETRATIONS AND CRACKS.

NOTE 2: CONTRACTOR OPTION TO PLACE 6" WIDE STRIP OR BAND OF WP-4 FROM SPRINGLINE ACROSS CROWN.



5 OPTIONAL SCOPE OF CRYSTALLINE WATERPROOFING TREATEMENT @ JOINT
TREATMENT AT PIPE INVERT & HAUNCH AREAS

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RAYMOND ROAD CULVERT PIPE RESTORATION

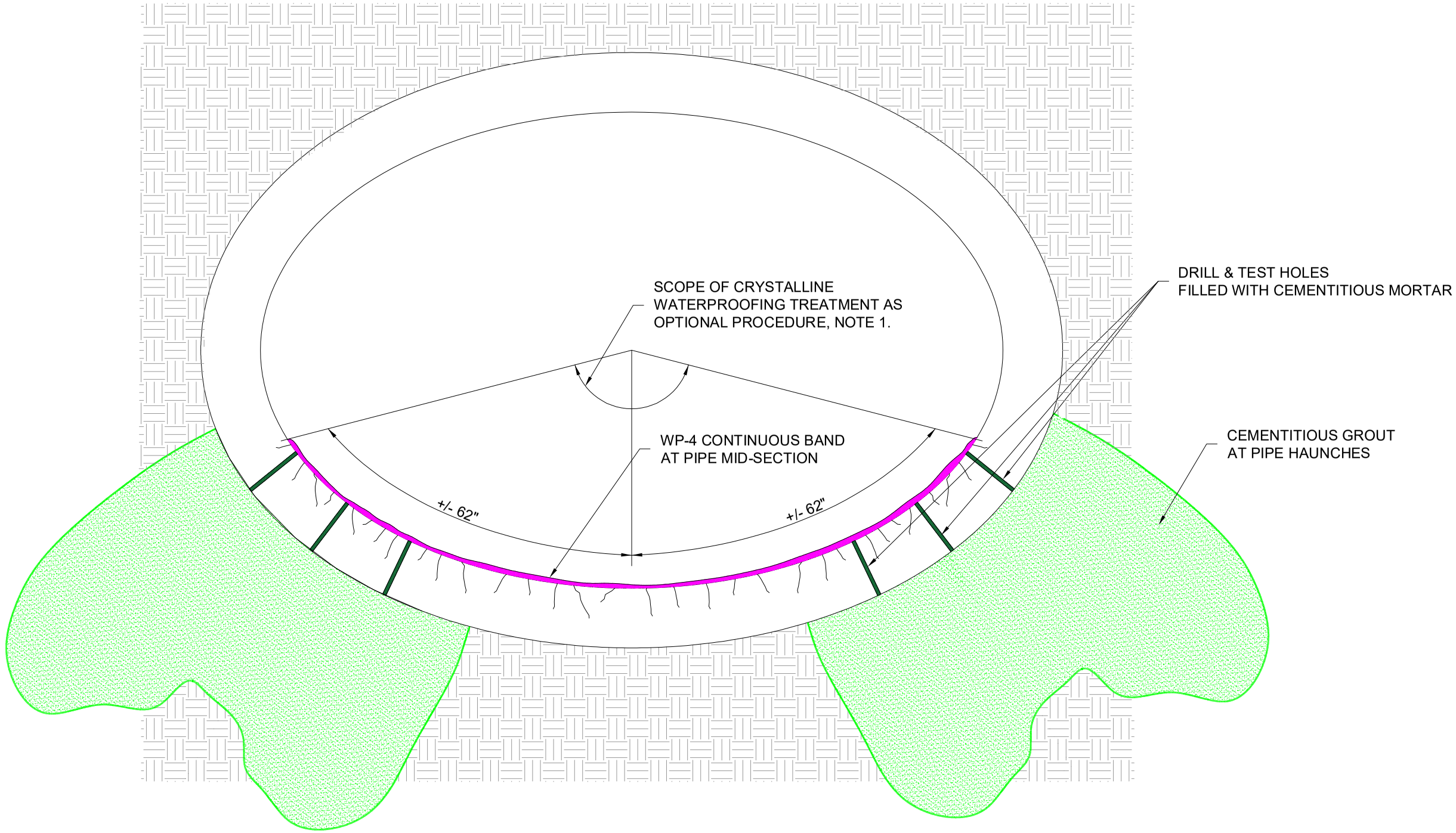
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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

SHEET: 5D

NOTE 1: CONTRACTOR OPTION TO TREAT 62" WIDE ZONE AT EACH SIDE OF INVERT WITH WP-4 IN LEIU OF 6"x6" SPOT TREATMENT AT ALL DRILL HOLES AND BANDING AT ALL CRACKS.



6 OPTIONAL SCOPE OF CRYSTALLINE WATERPROOFING TREATEMENT @ MID-SECTION
TREATMENT AT PIPE INVERT & HAUNCH AREAS

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RAYMOND ROAD CULVERT PIPE RESTORATION

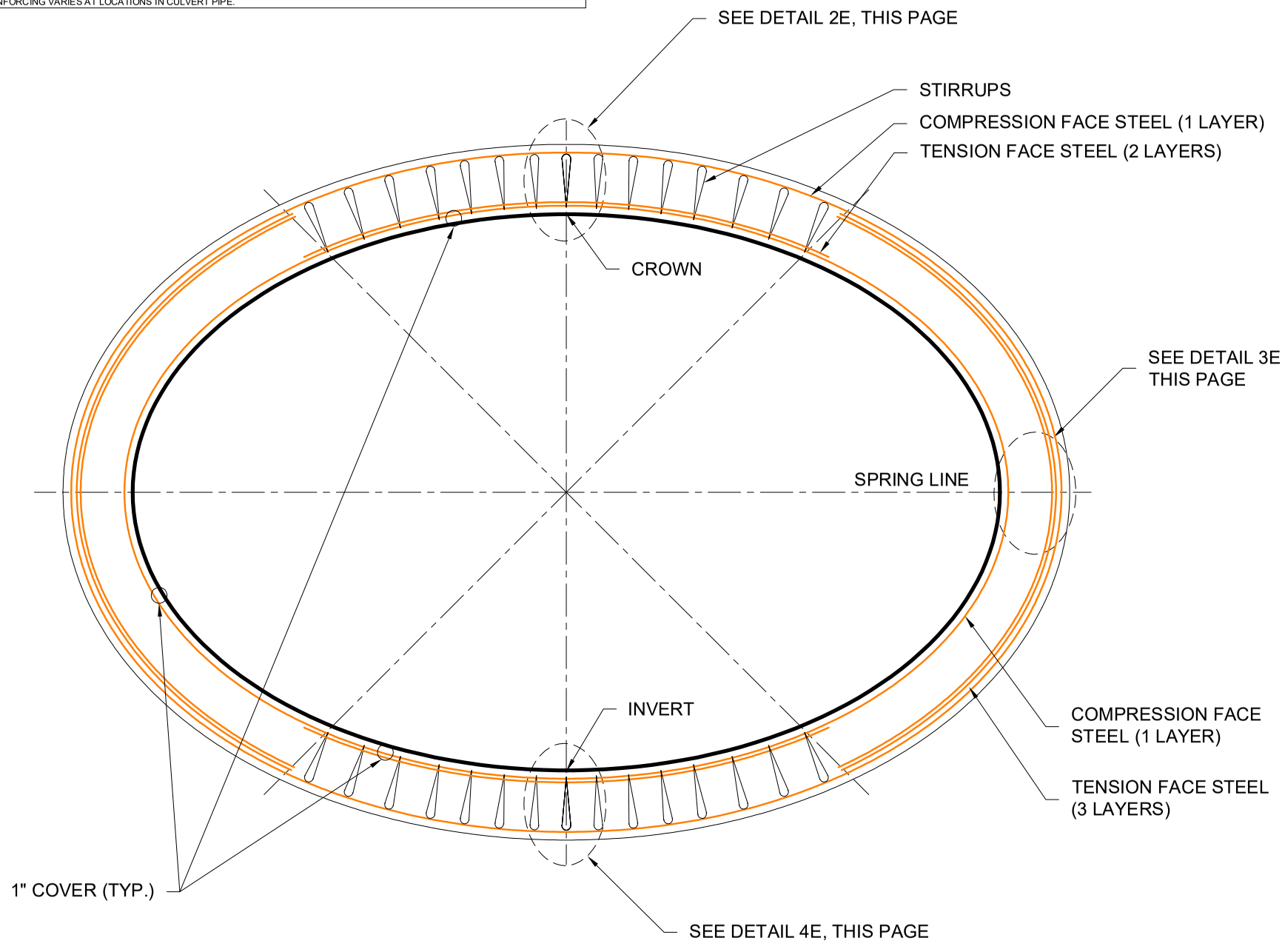
SHEET: 6D

TABLE OF CONTENTS

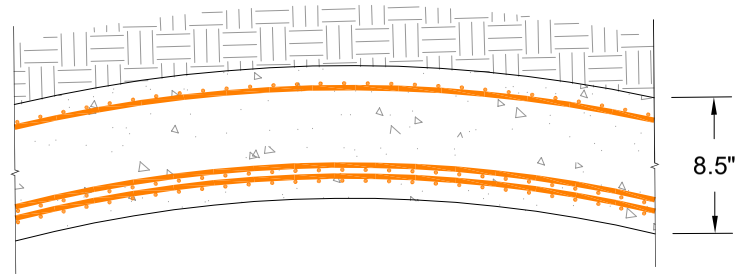
GENERAL SECTIONS	PAGES		
COVER PAGE	COVER		
PROJECT NARRATIVE	1		
TYPICAL REINFORCEMENT DRAWINGS	2-4		
TYPICAL PIPE JOINT CONDITIONS	5-9		
SCOPE OF WORK - WP-1, WP-2, SS-3, WP-4, WP-5, WP-6, WP-7, NOTE 1	10-25	SPECIFICATION SECTIONS	
"A" SERIES DRAWINGS	1A-17A	Section 03 64 13 Polyurethane Grout Crack-Joint Injection	WP-1
"B" SERIES DRAWINGS	1B-30B	Section 03 64 20 Acrylamide Grout Joint Injection, Soil Solidification	WP-2
"C" SERIES DRAWINGS	1C-13C	Section 03 61 10 Ultra-Fine Cement, Soil Stabilization	SS-3
"D" SERIES DRAWINGS	1D-6D	Section 07 16 16 Crystalline Waterproofing	WP-4
"E" SERIES DRAWINGS	1E-22E	Section 03 64 10 Polyacrylate Grout Crack Injection	WP-5
"F" SERIES DRAWINGS	1F-6F	Section 03 64 23 Epoxy Resin Crack Injection	WP-6
"G" SERIES DRAWINGS	1G-4G	Section 07 13 56 Thermoplastic Sheet Strip Seals	WP-7

GENERAL NOTES:

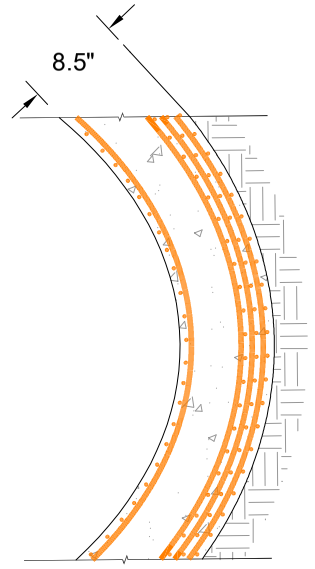
1. STEEL REINFORCING VARIES AT LOCATIONS IN CULVERT PIPE.



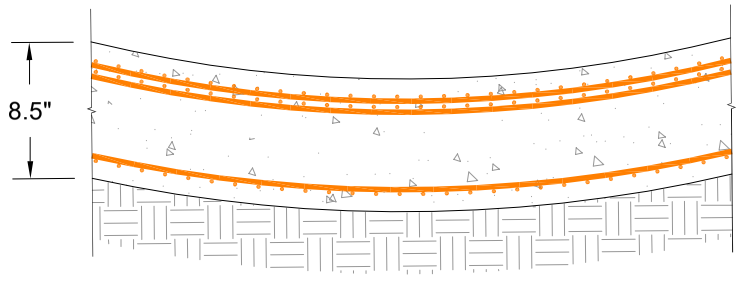
A PIPE END VIEW
Scale 1/2"=1'-0"



2E DETAIL
Scale 1/2"=1'-0"



3E DETAIL
Scale 1/2"=1'-0"



4E DETAIL
Scale 1/2"=1'-0"

1 POLYACRYLATE GROUT, CRACK INJECTION
FOR CRACK INJECTION BETWEEN (0.021 to 0.039) INCHES (21 to 39) MILS

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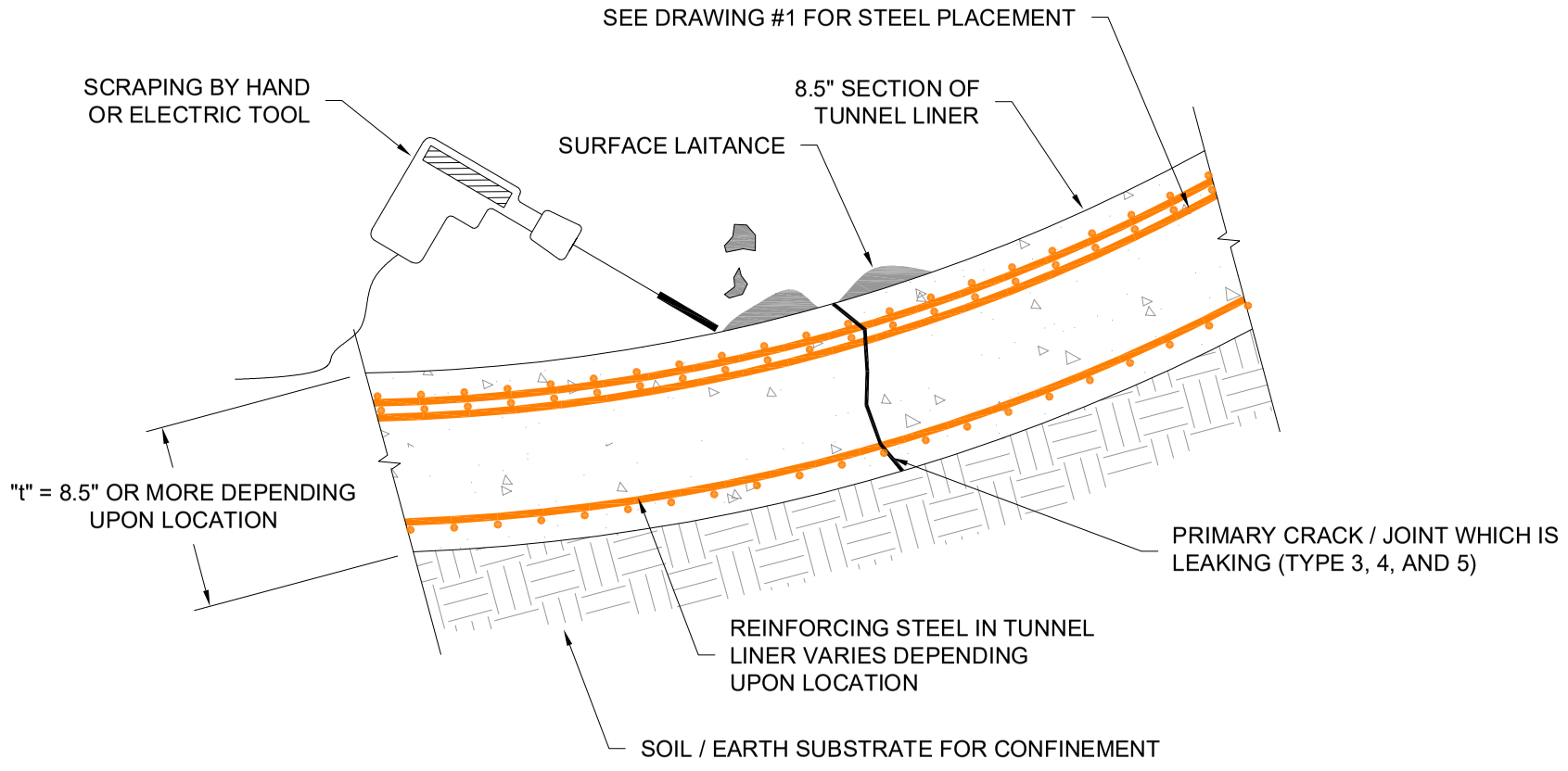
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 1E

1. ENSURE APPROPRIATE PPE IS BEING WORN BY ALL TRADES
2. SCRAPE, CHIP OR GRIND SURFACE CLEAN AS SURFACE PREPERATION
3. CHAIN DRAG OR SOUND AREA OF CONCRETE WITH ACOUSTIC IMPACT AROUND THE CRACK FOR DELAMINATIONS, ABOUT 8 INCHES OUT ON BOTH SIDES (BY OTHERS IF DEEMED NECESSARY)
4. LOCATE STEEL REINFORCING BAR, AND EMBEDDED COMMODITIES WITH GPR OR SIMILAR AND MARK ON SUBSTRATE
5. MARK LOCATIONS OF 5/8 INCH Ø DRILL HOLES FOR CRACK INTERCEPTION
   - 5.1. PERPENDICULAR TO CRACK LENGTH, MARK DRILL HOLE LOCATION (4-5) INCHES OUT [(t/2) = x]
   - 5.2. PARALLEL TO CRACK LENGTH, MARK OUT DRILL HOLE LOCATIONS ON ALTERNATING SIDES OF CRACK, (6-8) INCHES ON CENTER
   - 5.3. DRILL HOLE LOCATIONS CAN ALTERNATE IN DIRECTION, OR FROM ONE SIDE ONLY

DEGREES OF WATER LEAKAGE:

TYPE 1: COLOR CHANGE (DARKER) DUE TO SURFACE MOISTURE CONTENT
TYPE 2: WET TO TOUCH, SURFACE DAMPNESS, NO SUSTAINED TRAIL
TYPE 3: WEEPS & SEEPAGE, SUSTAINED TRAIL OF WETNESS
TYPE 4: CONTINUOUS DRIPPING, VISIBLE SURFACE FLOW
TYPE 5: GUSHING FLOW FROM HYDROSTATIC PRESSURE



2 POLYACRYLATE GROUT, CRACK INJECTION

INJECTION INTO CRACKS / PREPERATION

Key:

t = WALL / SLAB THICKNESS
1/3t = INTERCEPTION ZONE IN CRACK SECTION
x = MIN. DISTANCE FROM DRILL HOLE TO CRACK SHALL BE BETWEEN t/2 +/- (t/6)
⊖ = DRILL ANGLE TO SUBSTRATE SHALL TYPICALLY BE 45° AND CAN VARY +/- 15°
y = DRILL HOLE DIAMETER CAN BE 1/4", 3/8", 1/2", 5/8", AND 3/4"
t/2 = CENTERLINE OF ELEMENT
w = CRACK WIDTH
z = SPACING OF DRILL HOLES ALONG CRACK LENGTH SHALL BE BETWEEN t/2 to 2/3t

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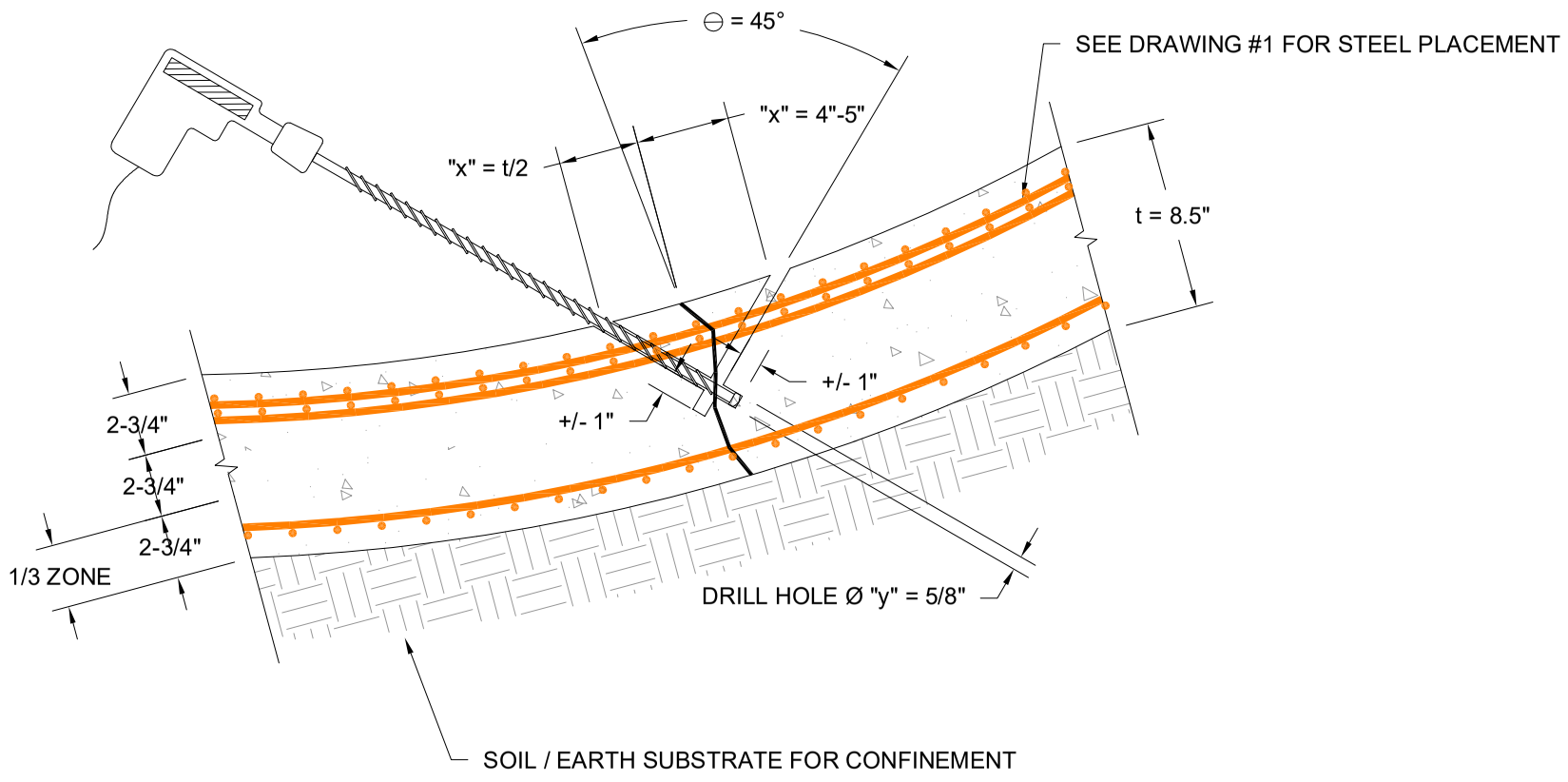
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 2E

1. ENSURE APPROPRIATE PPE IS BEING WORN BY ALL TRADES
2. MARK SPOTS FOR HAMMER DRILLING ALONG CRACK / JOINT LENGTH
3. DRILL HOLE LOCATIONS SHALL BE 4" to 5" OUT, ON EACH SIDE OF CRACK, APPROXIMATELY (6 to 8) INCHES ON CENTER. CAN USE ALTERNATING PATTERN. "x" = 6", z = 8" to 10".
4. BASED ON A DRILL ANGLE OF 45° FROM SURFACE OF CONCRETE, DRILL TO A DEPTH WHEREBY DRILL BIT EXTENDS PAST CRACK / JOINT, TYPICALLY BY +/- 1".
5. DIAGONAL DRILL DEPTH SHALL BE APPROXIMATELY 10".

DEGREES OF WATER LEAKAGE:

TYPE 1: COLOR CHANGE (DARKER) DUE TO SURFACE MOISTURE CONTENT
TYPE 2: WET TO TOUCH, SURFACE DAMPNESS, NO SUSTAINED TRAIL
TYPE 3: WEEPS & SEEPAGE, SUSTAINED TRAIL OF WETNESS
TYPE 4: CONTINUOUS DRIPPING, VISIBLE SURFACE FLOW
TYPE 5: GUSHING FLOW FROM HYDROSTATIC PRESSURE



3 POLYACRYLATE GROUT, CRACK INJECTION

INJECTION INTO CRACKS / DRILL PROCEDURE

Key:

t = WALL / SLAB THICKNESS
1/3t = INTERCEPTION ZONE IN CRACK SECTION
x = MIN. DISTANCE FROM DRILL HOLE TO CRACK SHALL BE BETWEEN t/2 +/- (t/6)
⊖ = DRILL ANGLE TO SUBSTRATE SHALL TYPICALLY BE 45° AND CAN VARY +/- 15°
y = DRILL HOLE DIAMETER CAN BE 1/4", 3/8", 1/2", 5/8", AND 3/4"
t/2 = CENTERLINE OF ELEMENT
w = CRACK WIDTH
z = SPACING OF DRILL HOLES ALONG CRACK LENGTH SHALL BE BETWEEN t/2 to 2/3t

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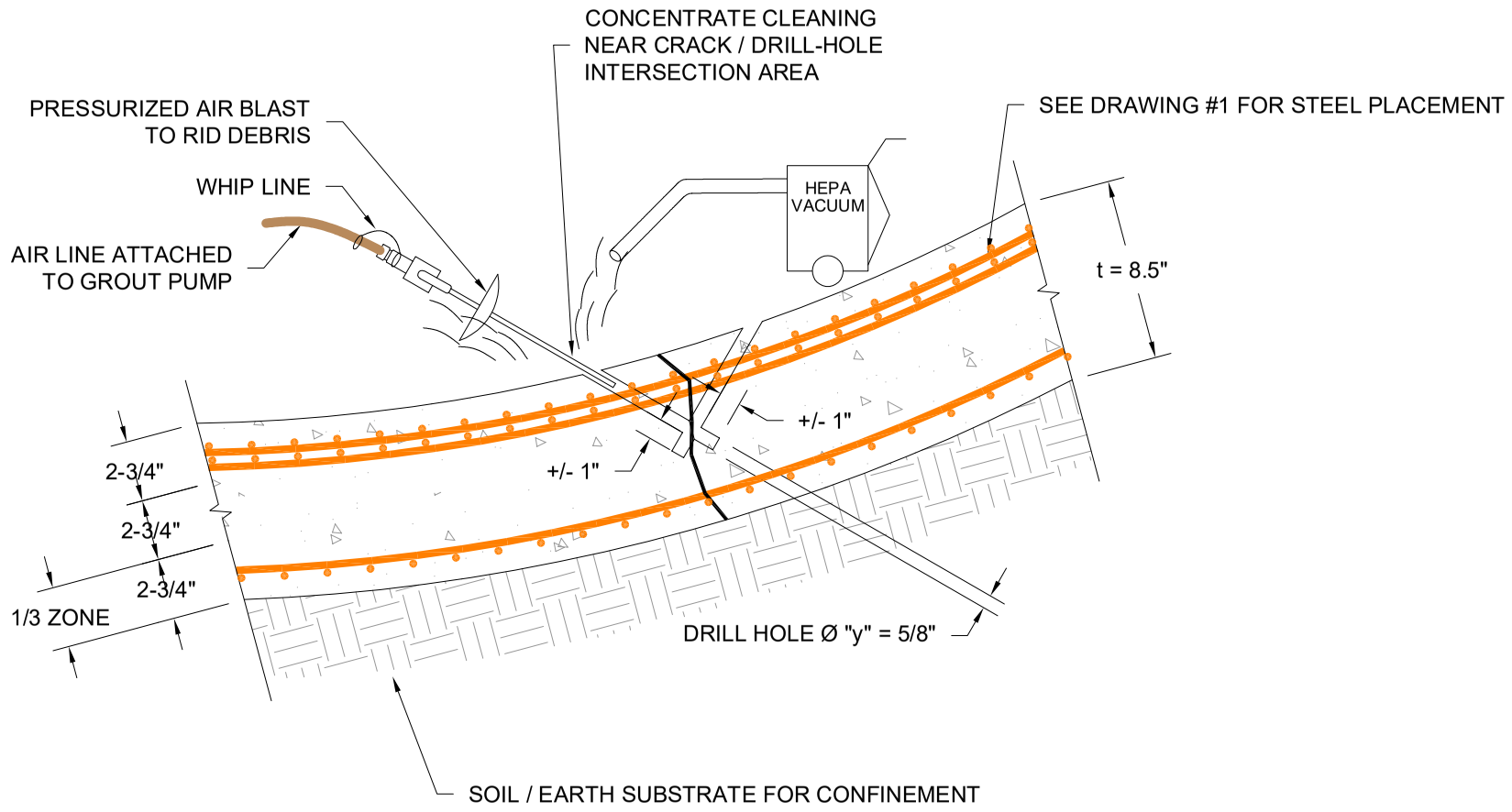
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 3E

1. AFTER HAMMER-DRILLING HOLE, USE AIR PRESSURIZED WAND TO RID DUST AND DEBRIS. FOLLOW OSHA STANDARDS FOR DUST CONTROL
2. BLOW COMPRESSED AIR DOWN DRILL HOLE TO RID HOLE OF DRILLING DEBRIS
3. VACUUM PROCEDURES CAN BE USED IN LIEU OF COMPRESSED AIR FLUSHING
4. SET-UP AND ACTIVATE WATER FLUSHING AND CHEMICAL GROUT SYSTEM (CGS) PRESSURE INJECTION PUMPS, SEE PAGES 7E-17E.

DEGREES OF WATER LEAKAGE:

TYPE 1: COLOR CHANGE (DARKER) DUE TO SURFACE MOISTURE CONTENT
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TYPE 5: GUSHING FLOW FROM HYDROSTATIC PRESSURE



4 POLYACRYLATE GROUT, CRACK INJECTION

INJECTION INTO CRACKS / CRACK FLUSHING

t = WALL / SLAB THICKNESS
1/3t = INTERCEPTION ZONE IN CRACK SECTION
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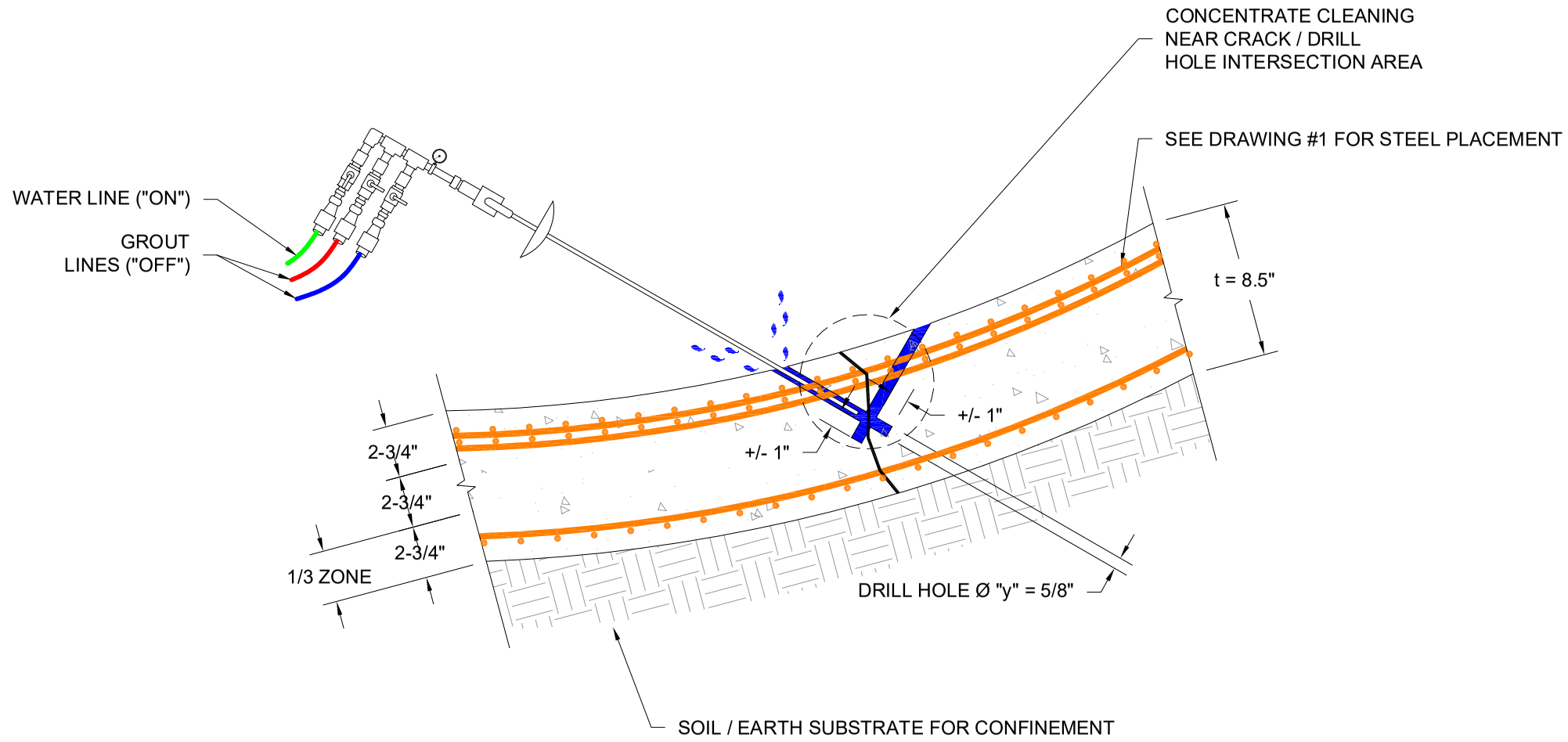
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 4E

1. AFTER AIR-BLASTING DRILL HOLE IS COMPLETED, ATTACH WATER FLUSING WAND TO "E" ASSEMBLY AND WATER BLAST DRILL HOLE TO RID FURTHER DEBRIS, CONCENTRATE CLEANING EFFORTS NEAR CRACK INTERCEPTION AREA
2. WATER PRESSURE FROM FLUSHING PUMP CAN VARY FROM (500 TO 1000) psig FOR CLEANING PURPOSES OF DRILL HOLE

DEGREES OF WATER LEAKAGE:

TYPE 1: COLOR CHANGE (DARKER) DUE TO SURFACE MOISTURE CONTENT
TYPE 2: WET TO TOUCH, SURFACE DAMPNESS, NO SUSTAINED TRAIL
TYPE 3: WEEPS & SEEPAGE, SUSTAINED TRAIL OF WETNESS
TYPE 4: CONTINUOUS DRIPPING, VISIBLE SURFACE FLOW
TYPE 5: GUSHING FLOW FROM HYDROSTATIC PRESSURE



5 POLYACRYLATE GROUT, CRACK INJECTION
INJECTION INTO CRACKS / CRACK CLEANING PROCEDURE

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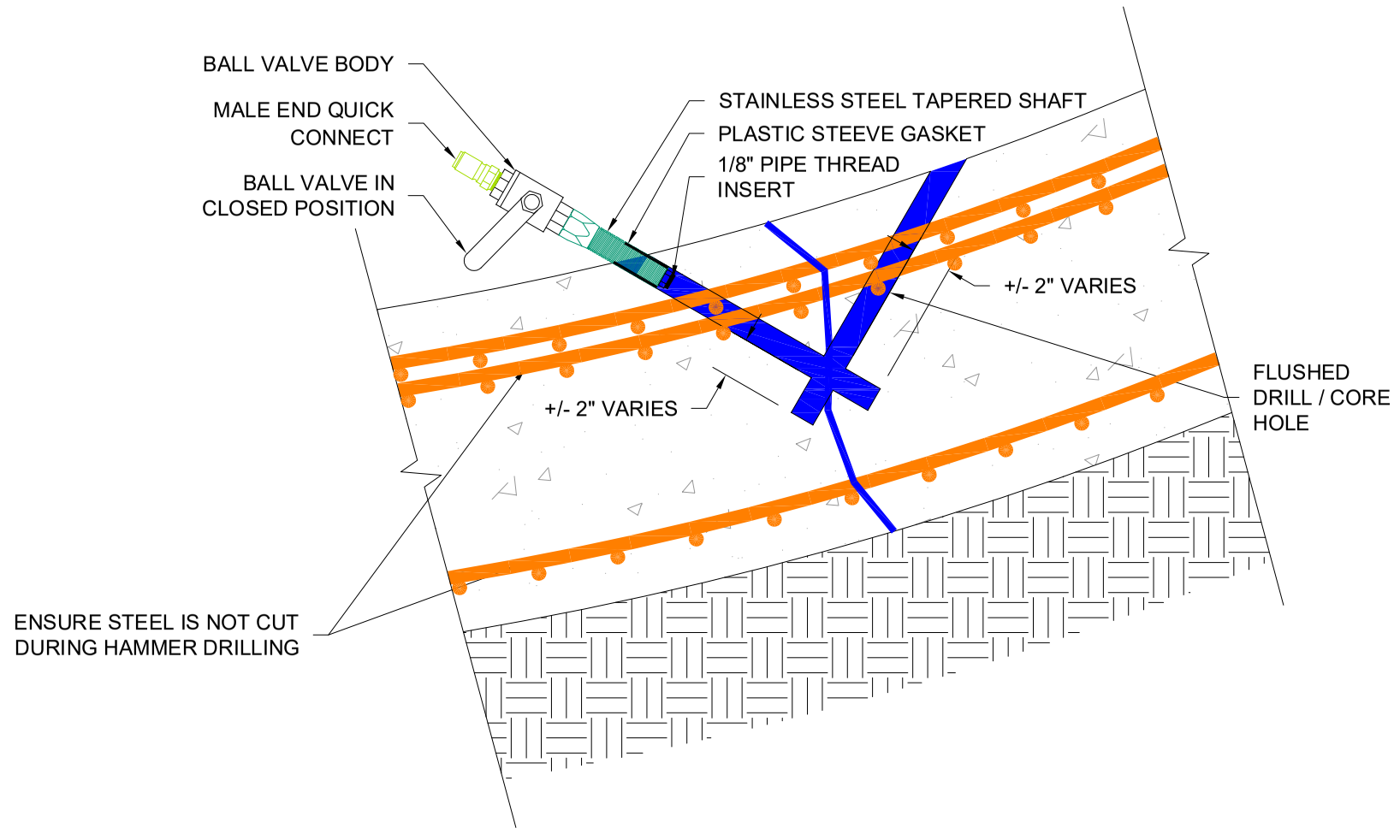
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 5E

1. PLACE PLASTIC SLEEVE ON BALL VALVE PACKER TAPERED SHAFT PRIOR TO PLACEMENT INTO 5/8" Ø DRILL HOLE
2. SPIN TAPERED SHAFT INTO DRILL HOLE TO ENSURE A WATERTIGHT FIT
3. ADJUST TIGHTNESS OF PACKER PRIOR TO PRESSURIZED WATER FLUSHING

DEGREES OF WATER LEAKAGE:

TYPE 1: COLOR CHANGE (DARKER) DUE TO SURFACE MOISTURE CONTENT
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6 POLYACRYLATE GROUT, CRACK INJECTION

INJECTION INTO CRACKS / PACKER PLACEMENT

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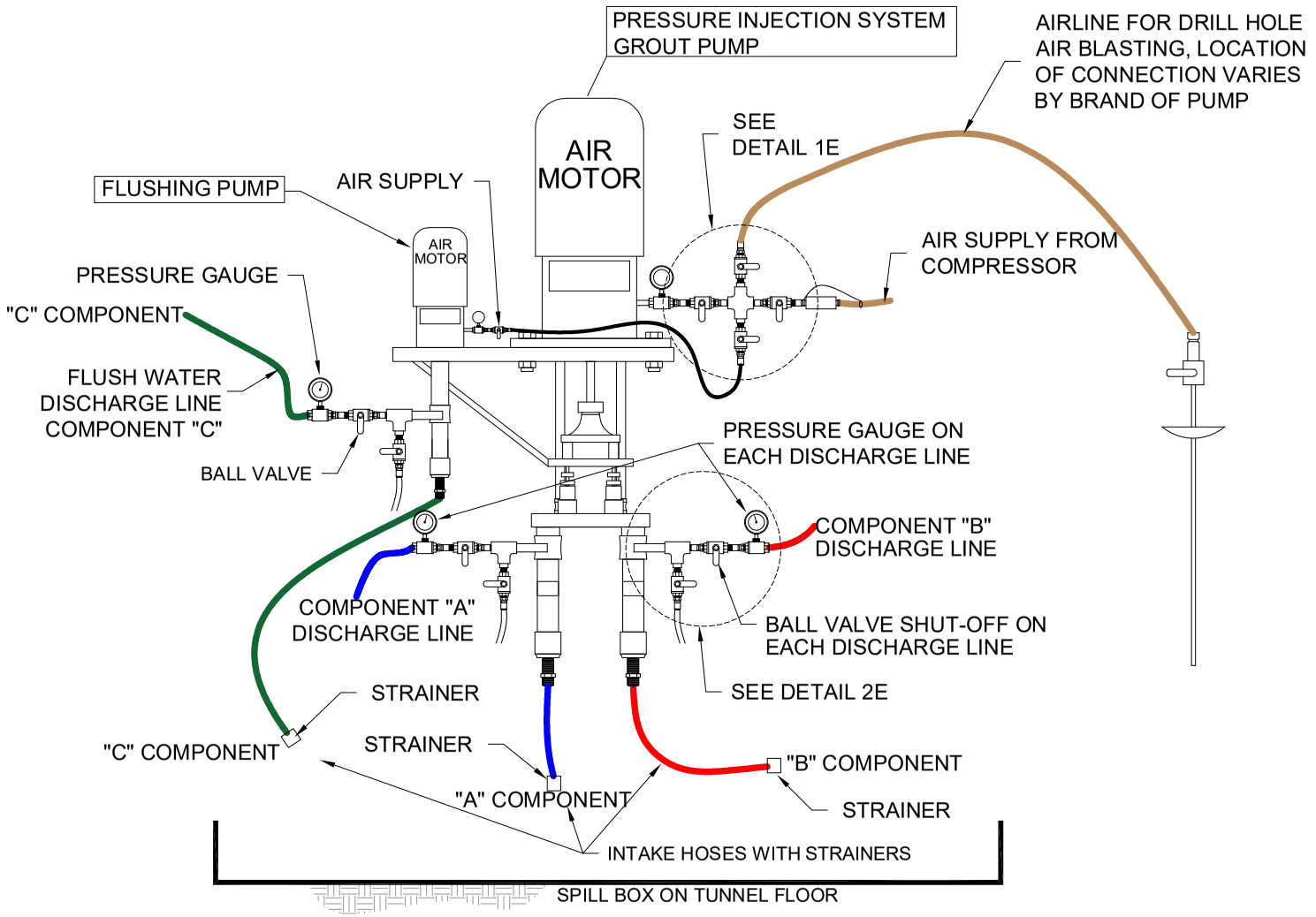
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 6E

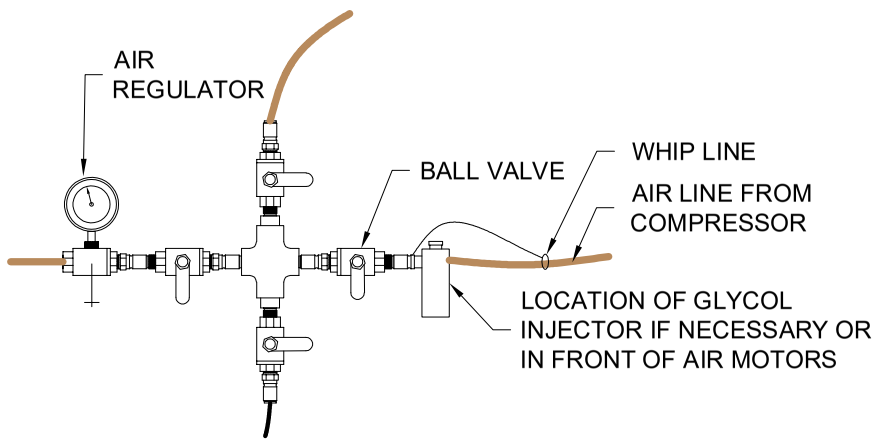
POLYACRYLATE GROUT EQUIPMENT AND PROCEDURES:

EQUIPMENT SETUP FOR CHEMICAL GROUT SYSTEM (CGS) - CLEANING, FLUSHING, PRESSURE INJECTION AND STORAGE

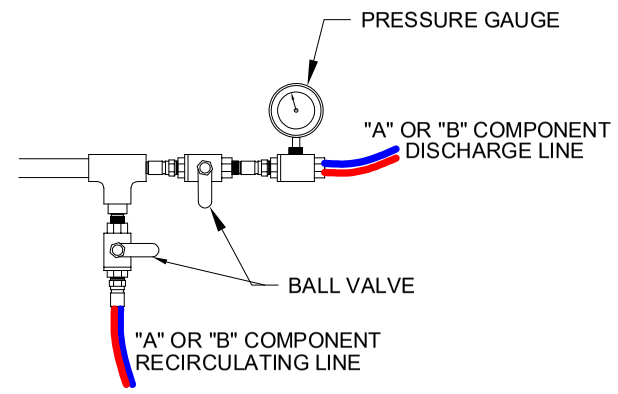


7 POLYACRYLATE GROUT, CRACK INJECTION

GROUT & FLUSHING PUMP SET-UP & COMPONENTS
NOTE: GROUT PUMP NOT SHOWN FOR CLARITY



1E AIR LINE SET-UP



2E DETAIL OF DISCHARGE AND RE-CIRCULATING LINES

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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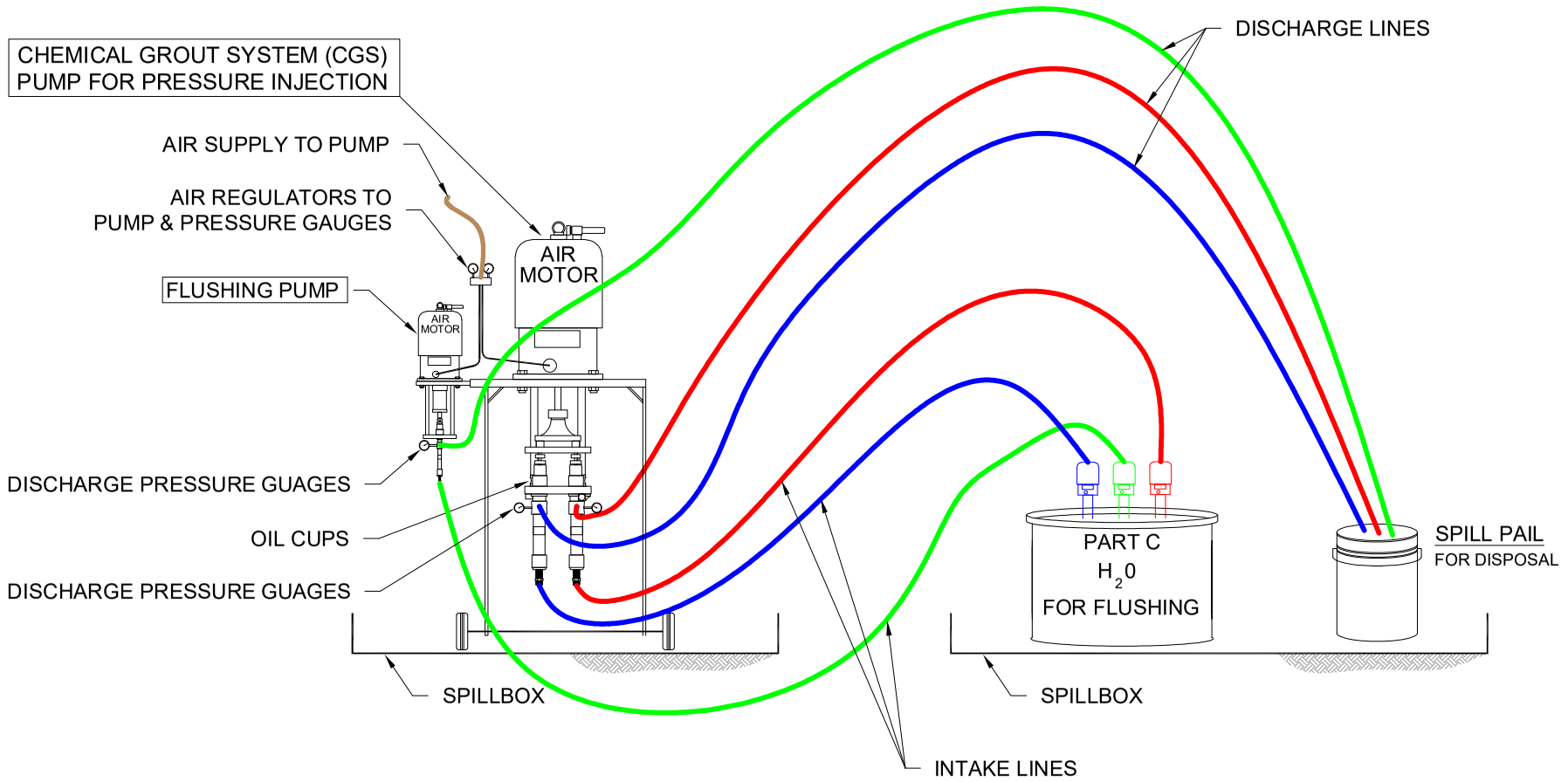
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 7E

1. SET PUMP ON / WITHIN SPILL BOX WITH TEAR RESISTANT MEMBRANE, RAISED ON SIDES
2. ATTACH AIR COMPRESSOR HOSE TO AIR LINE INTAKE ON PRESSURE INJECTION PUMP WITH APPROVED FITTING AND ANTI-WHIP LINE
3. INSTALL ETHYLENE GLYCOL LUBRICATOR IF COLD TEMPERATURES ARE PRESENT OR CONSTANT PUMPING IS REQUIRED
4. FILL PART "C" CONTAINER WITH CLEAN WATER
5. PLACE INTAKE LINE FROM FLUSHING PUMP AND BOTH "A" & "B" COMPONENT PRESSURE INJECTION PUMP LINE OF CHEMICAL GROUT SYSTEM (CGS) INTO PART "C" CONTAINER
6. PLACE ALL THREE DISCHARGE LINES IN SPILL PAIL
7. TURN CHEMICAL GROUT SYSTEM (CGS) PUMP ON AT LOW SPEED AND PRESSURE, ENSURE ALL THREE LINES DISCHARGE LIQUIDS INTO SPILL PAIL
8. CIRCULATE WATER THROUGH SYSTEM UNTIL ALL OIL FROM STORAGE IS FLUSHED OUT OF THE SYSTEM
9. CHECK TO ENSURE RATIO OF "A" & "B" COMPONENTS IS EQUAL OR WITHIN 10% OF EACH OTHER, SEE SHEET 12E
10. PUT INJECTION HEAD ("E" ASSEMBLY) ONTO (USE QUICK CONNECT FITTINGS) DISCHARGE LINES AND CLOSE BALL-VALVES, ENSURE NO LEAKAGE EXISTS AT HIGH FLUID PRESSURE
11. MAKE ADJUSTMENTS WHERE NECESSARY IF LEAKAGE AT MECHANICAL CONNECTIONS OCCUR



* NOTE:
- RE-CIRCULATING DISCHARGE LINES NOT SHOWN FOR CLARITY
- PUMP IS USUALLY STORED WITH VEGETABLE OIL IN SYSTEM. THIS IS NON-HAZARDOUS AND CAN EASILY BE DISPOSED OF.

8 POLYACRYLATE GROUT, CRACK INJECTION
PUMP FLUSHING OR STORAGE OIL OUT FROM SYSTEM
GROUT PUMP PREPERATION

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RAYMOND ROAD CULVERT PIPE RESTORATION

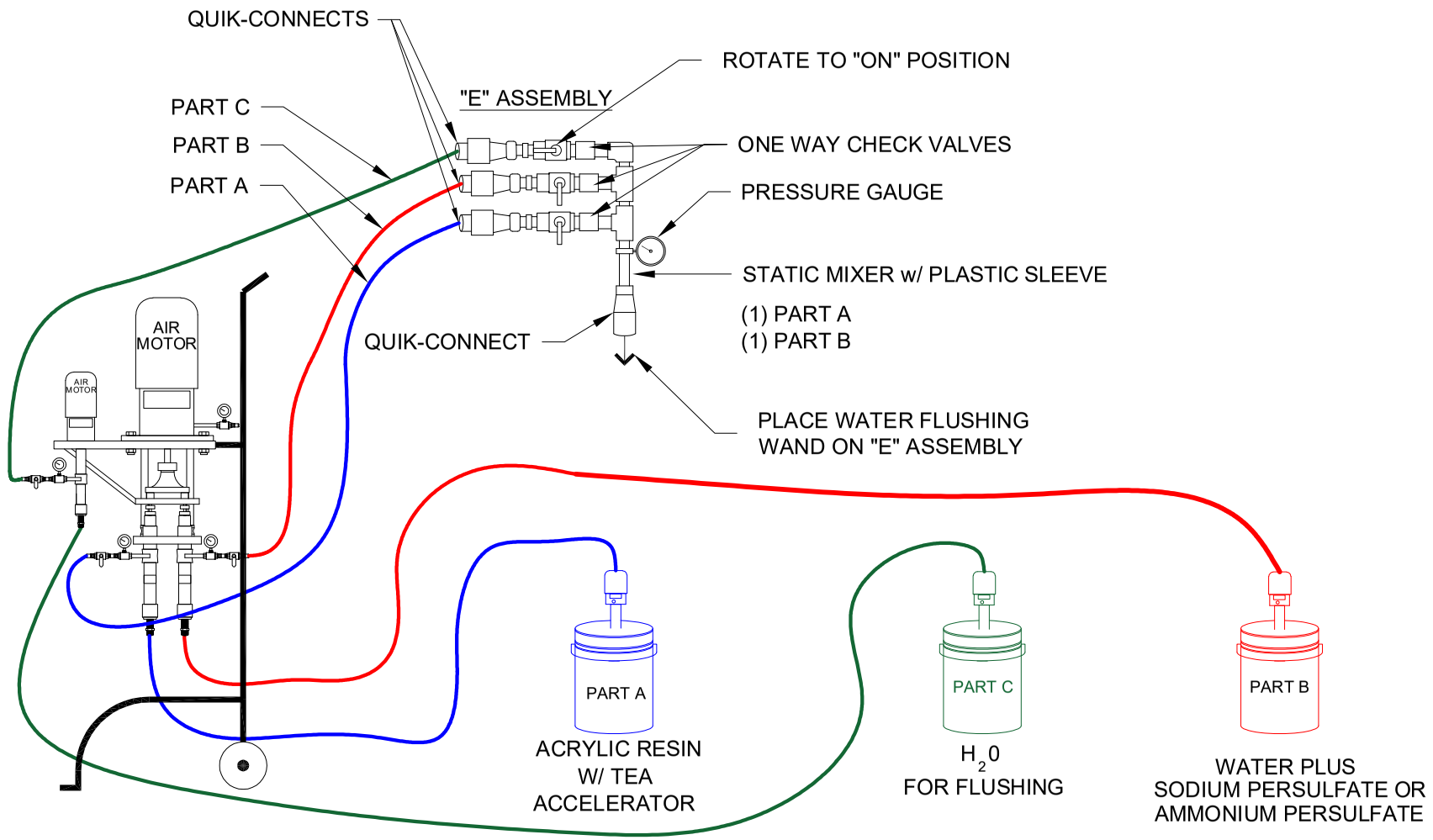
SHEET: 8E

WATER FLUSHING DRILL HOLES:

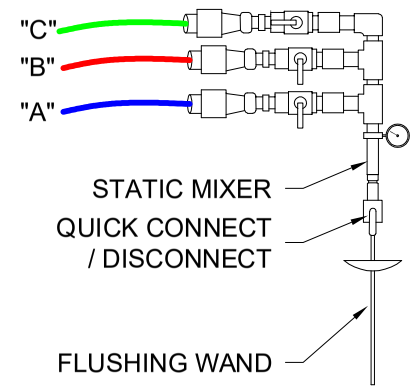
1. OPEN BALL VALVE ON "E" ASSEMBLY FOR COMPONENT "C", WATER
2. CLOSE BALL VALVES ON "E" ASSEMBLY FOR COMPONENTS "A" & "B", CHEMICAL GROUT
3. PLACE WATER BLAST WAND ON "E" ASSEMBLY
4. TURN FLUSHING PUMP "ON", ADJUST TO DESIRED WATER BLAST PRESSURE
5. PLACE FLUSHING WAND DOWN DRILL HOLE TO FLUSH DRILLING DEBRIS FROM HOLE

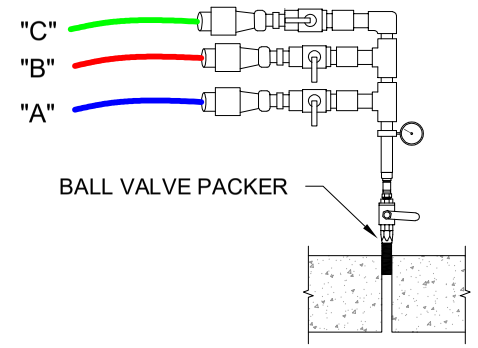
WATER FLUSHING CRACK:

1. REMOVE WATER BLAST WAND FROM "E" ASSEMBLY
2. PLACE BALL-VALVE PACKER ON DRILL HOLE, SECURE & TIGHTEN
3. PLACE "E" ASSEMBLY ON BALL VALVE PACKER
4. TURN FLUSHING PUMP ON, ADJUST PRESSURE TO ENSURE WATER FLUSHES OUT CRACK 6" ON EACH SIDE OF DRILL HOLE
5. TURN FLUSHING PUMP OFF - REMOVE "E" ASSEMBLY FROM PACKER



"E" ASSEMBLY





9 POLYACRYLATE GROUT, CRACK INJECTION

CLASSIC SET-UP FOR FLUSHING GROUT & PUMPING WATER FOR CRACK / JOINT FLUSHING
NOTE: RE-CIRCULATING LINES NOT SHOWN FOR CLARITY
NOTE: SPILL BOX NOT SHOWN FOR CLARITY

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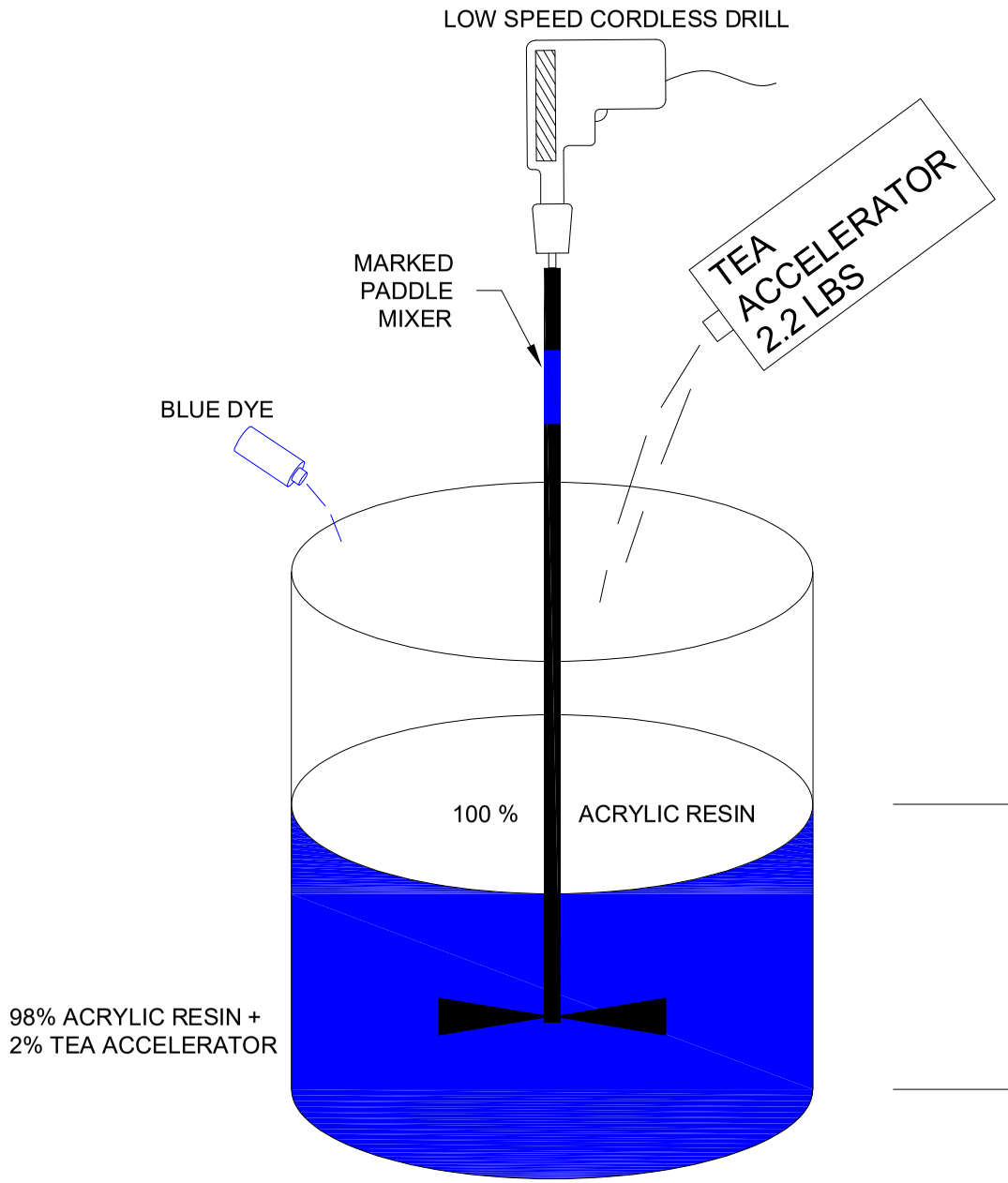
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 9E

"A" COMPONENT MIXING

1. POSITION 100% ACRYLIC RESIN PAIL ON SPILL PAD
2. OPEN LID ON RESIN PAIL
3. ADD 1 BOTTLE (2.2 LBS) OF BLUE ACCELERATOR TO RESIN PAIL
4. ADD 3-4 TEASPOONS OF BLUE DYE TO RESIN PAIL
5. PLACE PADDLE IN "A" RESIN PAIL AND SLOWLY MIX FOR 2 MINUTES
6. MEASURE TEMPERATURE OF "A" COMPONENT RESIN
7. HEAT OR COOL IF NECESSARY
8. PLACE LID BACK ON PAIL UNTIL READY FOR USE
9. MARK "A" RESIN PADDLE WITH BLUE LABEL OR TAPE TO ENSURE AGAINST CROSS-CONTAMINATION IN "B" COMPONENT

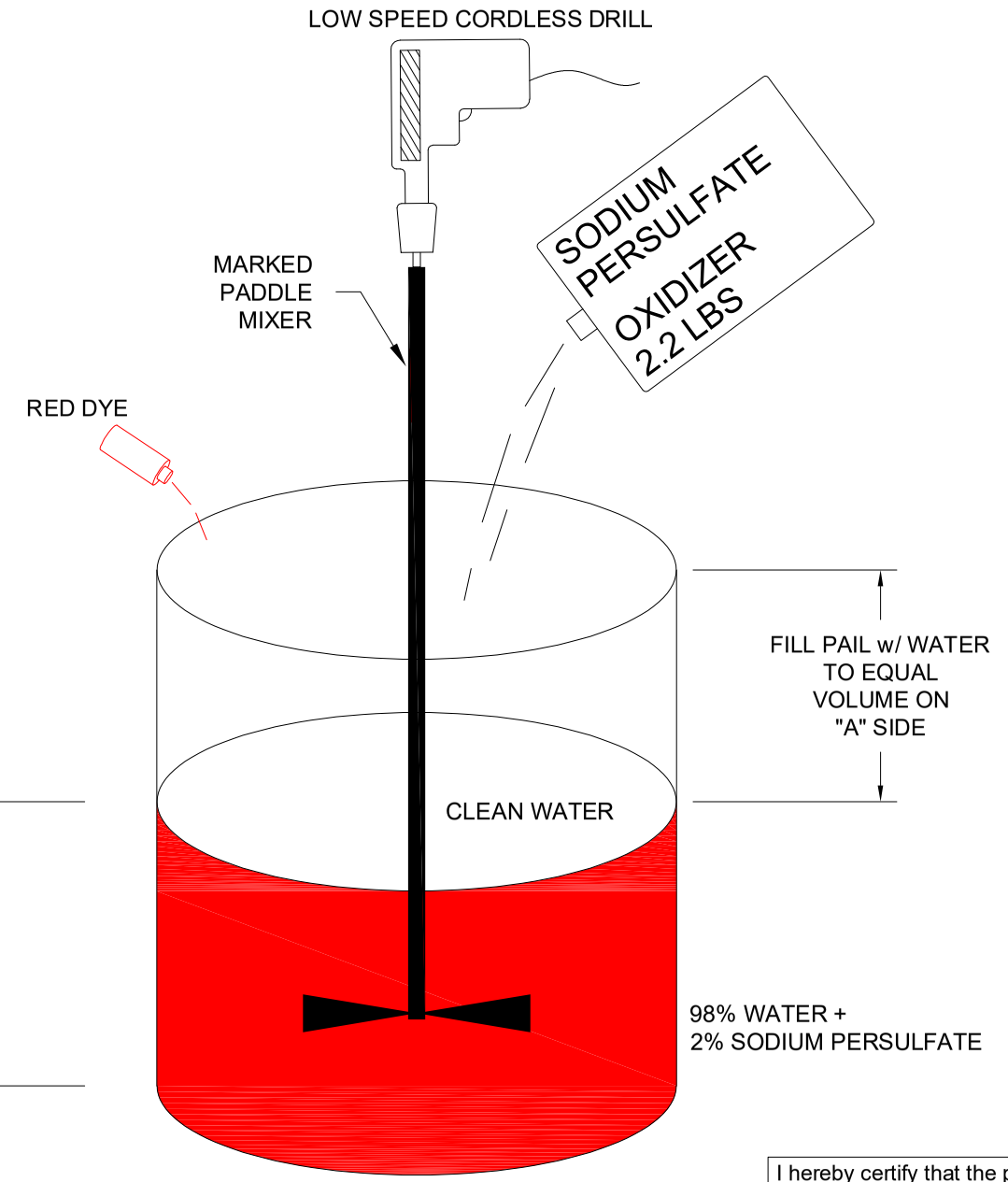


10A "A" COMPONENT MIXING
"A" RESIN PAIL

"A" + "B" EQUAL

"B" COMPONENT MIXING

1. POSITION OXIDIZER PAIL AND FILL WITH 4 GALLONS OF CLEAN WATER
2. ADD 1 BAG (2.2 LBS) OF WHITE POWDER (SODIUM PERSULFATE) TO WATER
3. ADD 2-3 TEASPOONS OF RED DYE TO OXIDIZER PAIL
4. PLACE PADDLE IN "B" RESIN PAIL AND SLOWLY MIX FOR 2 MINUTES
5. MEASURE TEMPERATURE OF "B" COMPONENT FLUID
6. HEAT OR COOL IF NECESSARY
7. PLACE LID BACK ON PAIL UNTIL READY FOR USE
8. MARK "B" RESIN PADDLE WITH RED LABEL OR TAPE TO ENSURE AGAINST CROSS-CONTAMINATION IN "A" COMPONENTS
9. FILL PAIL TO AN EQUAL VOLUME AS ON "A" SIDE



10B "B" COMPONENT MIXING
"B" RESIN PAIL

10 POLYACRYLATE GROUT, CRACK INJECTION
MIXING / FORMULATING A&B COMPONENTS

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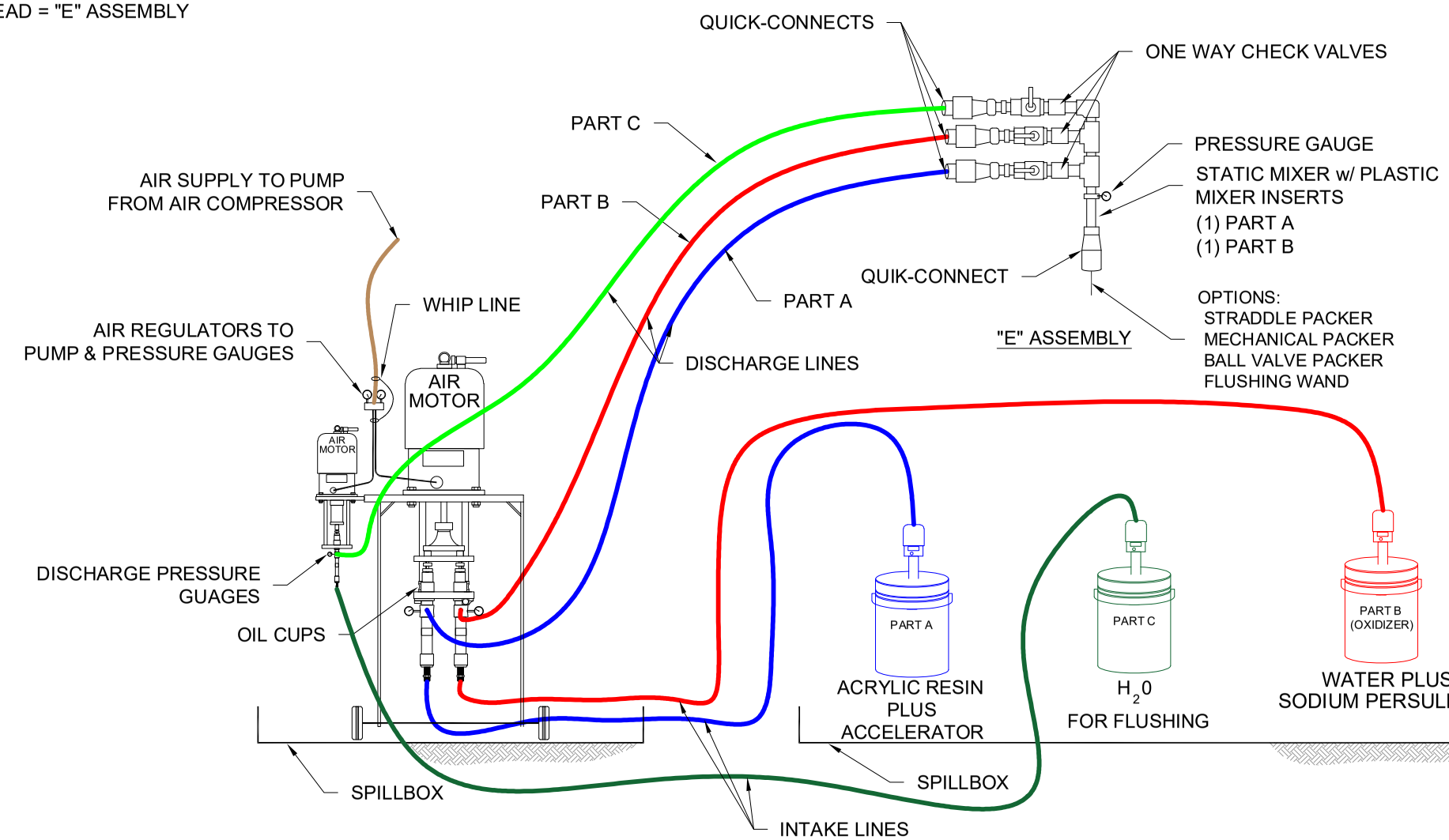
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 10E

1. REFER TO SHEET 12 AND 13, FOR GEL-TIME CUP TEST, AND RATIO CHECK
2. NOTE: STATIC MIXER NEEDS TO BE FLUSHED WITH WATER PRIOR TO GEL-TIME REACTION
3. TURN ON AIR PRESSURE TO CHEMICAL GROUT SYSTEM PUMP, TURN OFF AIR PRESSURE TO FLUSHING PUMP
4. REGULATE AIR PRESSURE TO OBTAIN A STEADY FLOW OF MATERIAL THROUGH INJECTION GUN*
5. HOOK UP INJECTION HEAD* TO QUICK CONNECT OF BALL VALVE PACKER ASSEMBLY
6. START INJECTION PRESSURE AT (100-200) psig, MONITOR PISTONS ON PUMP FOR FLOW
7. CONTINUE PUMPING UNTIL MIXED GROUT EXTENDS HALF WAY TO EACH ADJACENT PORT
8. IF RESISTANCE TO CHEMICAL GROUT FLOW DOES NOT ALLOW PISTON MOVEMENT, INCREASE PRESSURE TO AIR MOTOR ON CHEMICAL GROUT SYSTEM (CGS) PRESSURE INJECTION PUMP IN 100 psig INCREMENTS UNTIL FLOW OCCURS
9. DO NOT EXCEED 700 psig AT DISCHARGE PRESSURE GAUGES
10. IF CHEMICAL GROUT DOES NOT CONTINUE TO FLOW, REMOVE "E" ASSEMBLY FROM PACKER, FLUSH LINE WITH WATER, REPEAT PROCESS OF DRILLING NEW DRILL HOLE IN VICINITY OF "DEAD HOLE". NOTE THAT THIS SHOULD NOT OCCUR BECAUSE THE HOLE WAS TESTED WITH WATER PREVIOUSLY.
11. MOVE TO NEXT PACKER ASSEMBLY.

* INJECTION GUN = INJECTION HEAD = "E" ASSEMBLY



* NOTE - RE-CIRCULATING DISCHARGE LINES NOT SHOWN FOR CLARITY

11 POLYACRYLATE GROUT, CRACK INJECTION
CHEMICAL GROUT INJECTION OPERATION / PLUMBING

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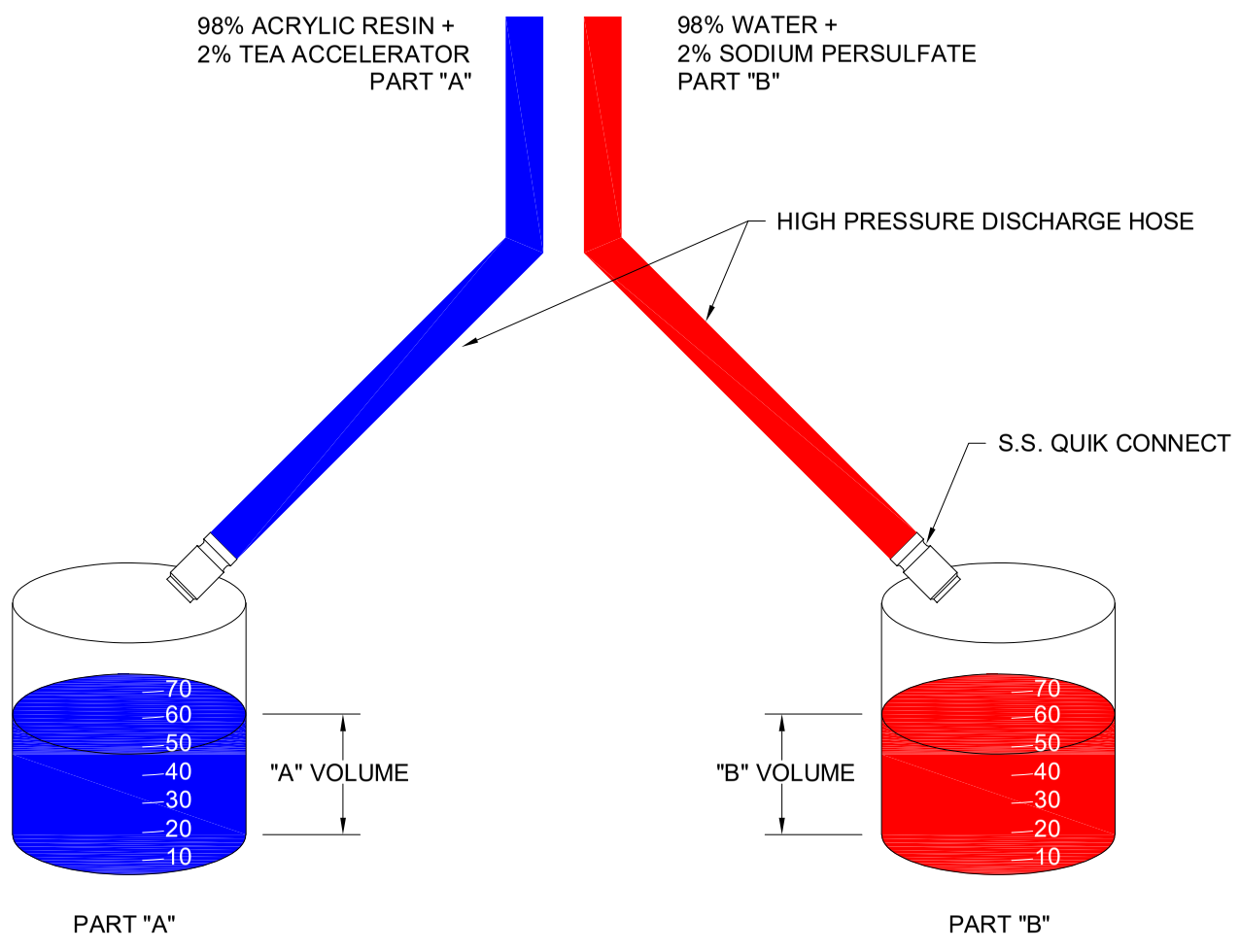
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 11E

1. PRIOR TO PUMPING:
   1.1. DISCONNECT "E" OR "F" ASSEMBLY
   1.2. PUMP PARTS "A" & "B" INTO MEASURING CUPS TO ENSURE PROPER 1-TO-1 RATIO, TOLERANCE MAY BE 10% EITHER WAY
   1.3. ADJUST PUMP STROKE LENGTH IF NOT IN RATIO OF 1-TO-1
2. RATIO BALANCE CAN BE INFLUENCED BY PARTICLES OR DEBRIS BUILD UP IN VALVES OF PUMP



12 POLYACRYLATE GROUT, CRACK INJECTION
QA / QC, 1-to-1 RATIO CHECK

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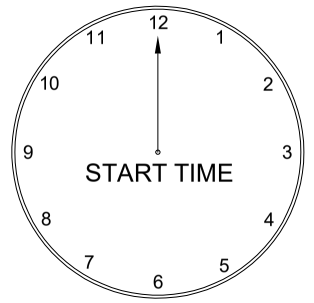
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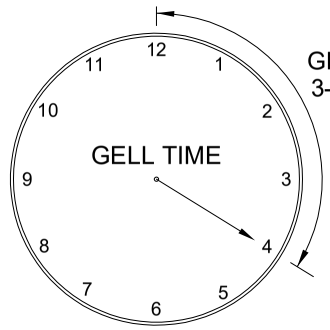
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 12E

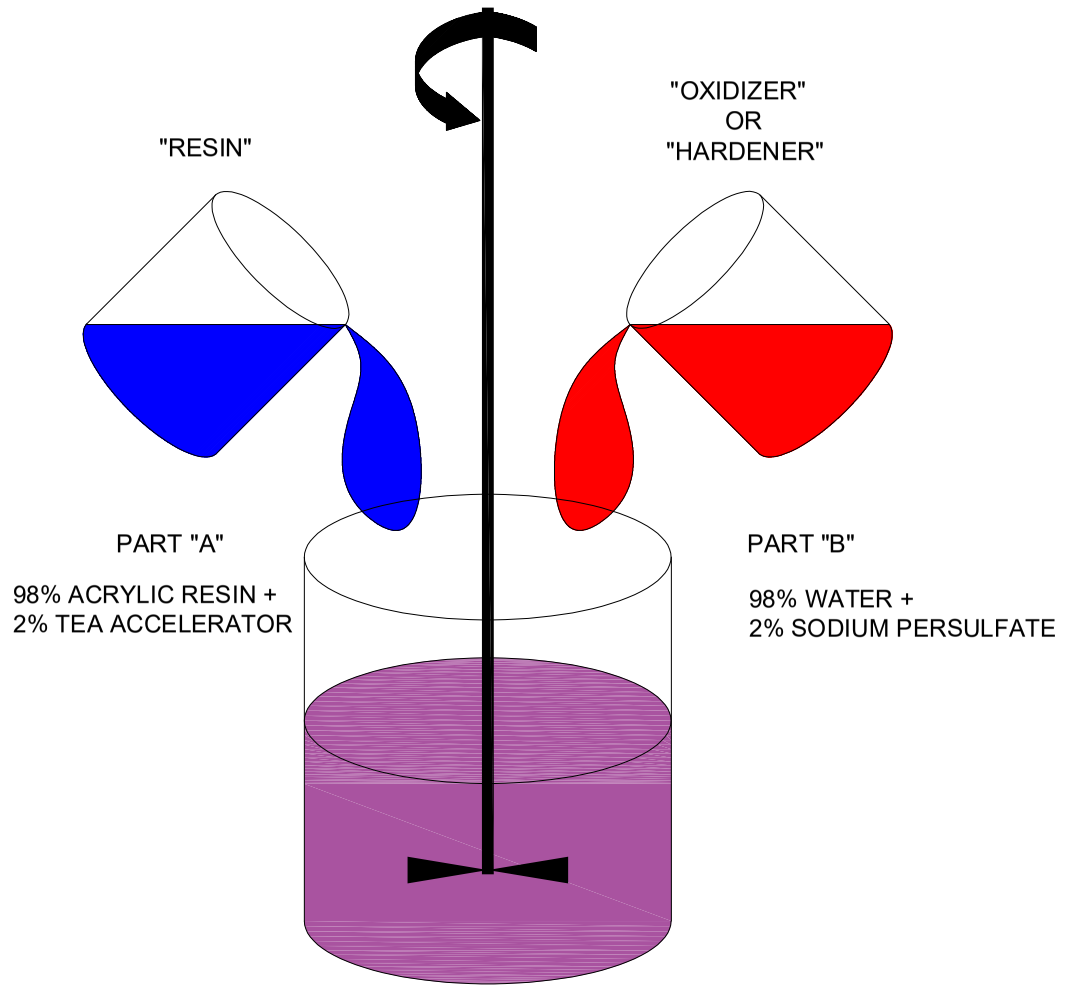
1. TAKE "A" & "B" COMPONENTS AND MIX TOGETHER, NOTE START TIME.
2. AFTER SHORT PERIOD (30 SECONDS TO 3 MINUTES) GROUT VISCOSITY INCREASES.
3. RATHER QUICKLY GROUT SOLIDIFIES INTO A SOLID MASS. NOTE GEL TIME.
4. IF GEL TIME IS TOO SHORT:
   - 4.1. REDUCE TEA BY 20% INTO PART "A"
   - 4.2. REDUCE HARDENER IN PART "B" BY 20%.
   - 4.3. MEASURE NEW GEL TIME.
5. IF GEL TIME IS TOO LONG:
   - 5.1. INCREASE TEA BY 20% INTO PART "A"
   - 5.2. INCREASE HARDENER IN PART "B" BY 20%
   - 5.3. MEASURE NEW GEL TIME
6. GEL-TIME IS INFLUENCED BY FLUID TEMPERATURE "A" & "B" RESIN TEMPERATURE CAN BE VARIED FROM 40° TO 120° F.
7. PAIL AND/OR DRUM HEATERS ARE COMMONLY USED IF WARMING IS REQUIRED.

* HARDENER IS CALLED SODIUM PERSULFATE, ALSO CALLED "OXIDIZER".





GEL-TIME
3-5 MINUTES



GEL TIME INFLUENCED BY:

1. TEMPERATURE OF LIQUIDS "A" & "B"
2. pH OF WATER ON "B" SIDE
3. IRON CONTENT IN WATER IN "B" SIDE
4. CONCENTRATIONS OF ACCELERATOR AND OXIDIZER IN PAILS

13 POLYACRYLATE GROUT, CRACK INJECTION
GEL TIME CHECK

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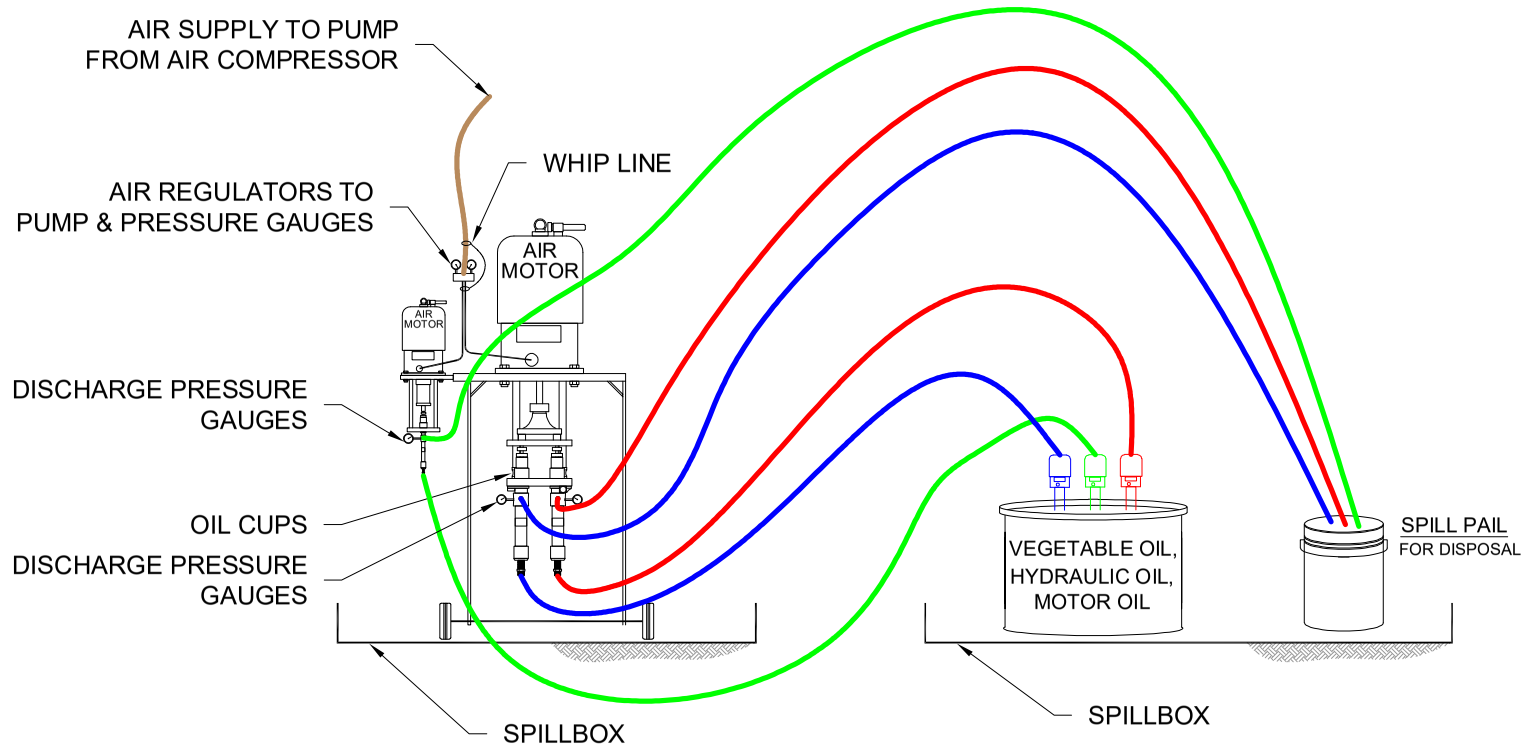
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RAYMOND ROAD CULVERT PIPE RESTORATION

1. UPON COMPLETION OF PRESSURE INJECTION OPERATIONS, FLUSH PUMPS (CHEMICAL GROUT SYSTEMS (CGS) PRESSURE INJECTION PUMP AND ATTACHED FLUSHING PUMP) WITH DETERGENT/SOAP AND WATER INTO SPILL PAIL
2. AFTER FLUSHING, PUMP VEGETABLE, OR MOTOR OIL IN (CHEMICAL GROUT SYSTEMS (CGS) PRESSURE INJECTION PUMP AND ATTACHED FLUSHING PUMP) SYSTEM FOR STORAGE AND UNTIL NEXT USAGE.



* NOTE - RE-CIRCULATING DISCHARGE LINES NOT SHOWN FOR CLARITY

14 POLYACRYLATE GROUT, CRACK INJECTION

FLUSHING GROUT PUMP AND PREPARING FOR STORAGE
GROUT PUMP CLEANUP

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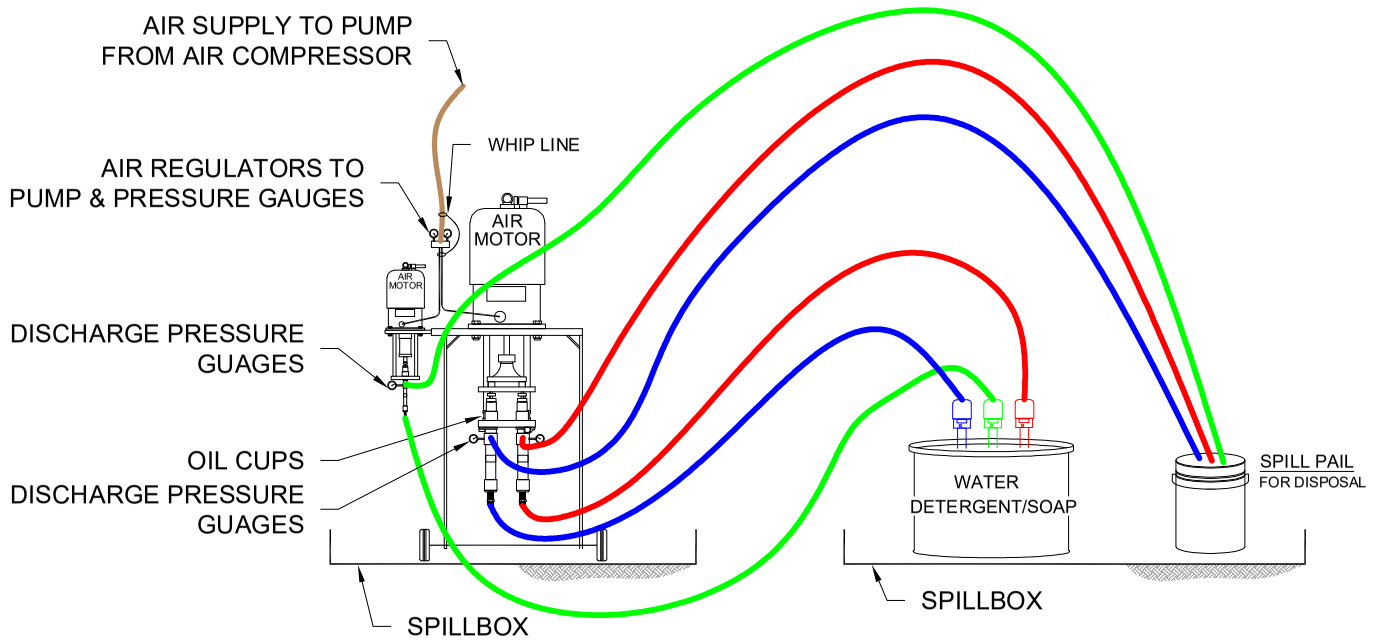
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 14E

1. UPON COMPLETION OF PRESSURE INJECTION OPERATIONS, FLUSH PUMPS (CHEMICAL GROUT SYSTEMS (CGS) PRESSURE INJECTION PUMP AND ATTACHED FLUSHING PUMP) WITH DETERGENT/SOAP AND WATER INTO SPILL PAIL
2. AFTER FLUSHING, PUMP VEGETABLE, OR MOTOR OIL IN (CHEMICAL GROUT SYSTEMS (CGS) PRESSURE INJECTION PUMP AND ATTACHED FLUSHING PUMP) SYSTEM FOR STORAGE AND UNTIL NEXT USAGE.



* NOTE - RE-CIRCULATING DISCHARGE LINES NOT SHOWN FOR CLARITY

15 POLYACRYLATE GROUT, CRACK INJECTION
FLUSHING GROUT PUMP AND PREPARING FOR STORAGE
GROUT PUMP CLEANUP

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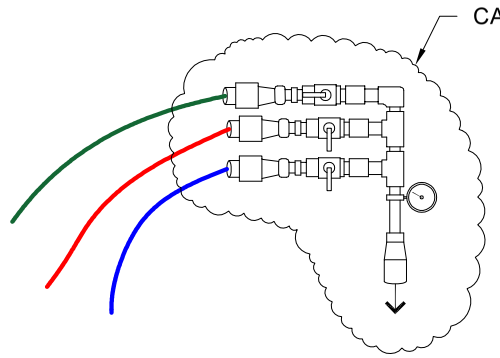
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RAYMOND ROAD CULVERT PIPE RESTORATION

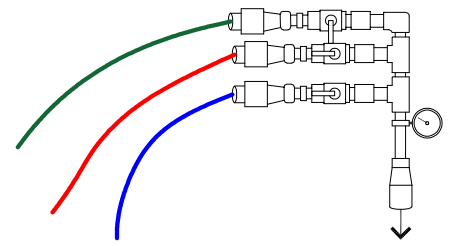
WATER FLUSHING LINE IN OPEN POSITION, MEANING PRESSURIZED WATER FLOW TO OCCUR FROM FLUSHING PUMP



BALL VALVES, CLOSED POSITION FOR CHEMICAL GROUT FLOW FROM GROUT PUMP

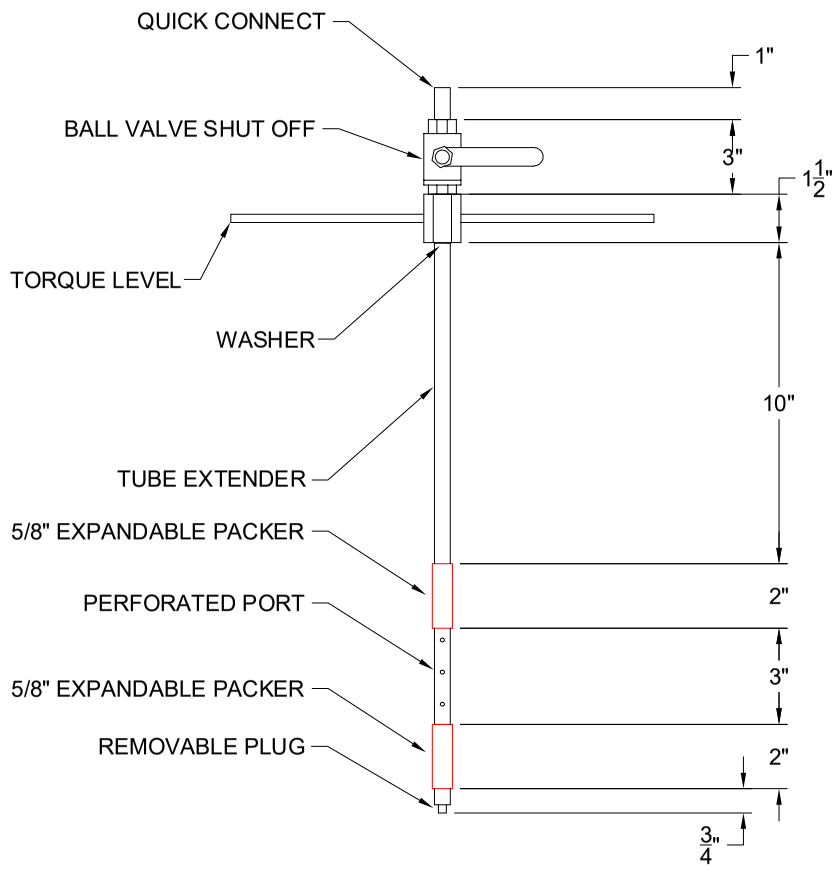
"E" ASSEMBLY

WATER FLUSHING LINE IN CLOSED POSITION, MEANING NO WATER FLOW FROM FLUSHING PUMP

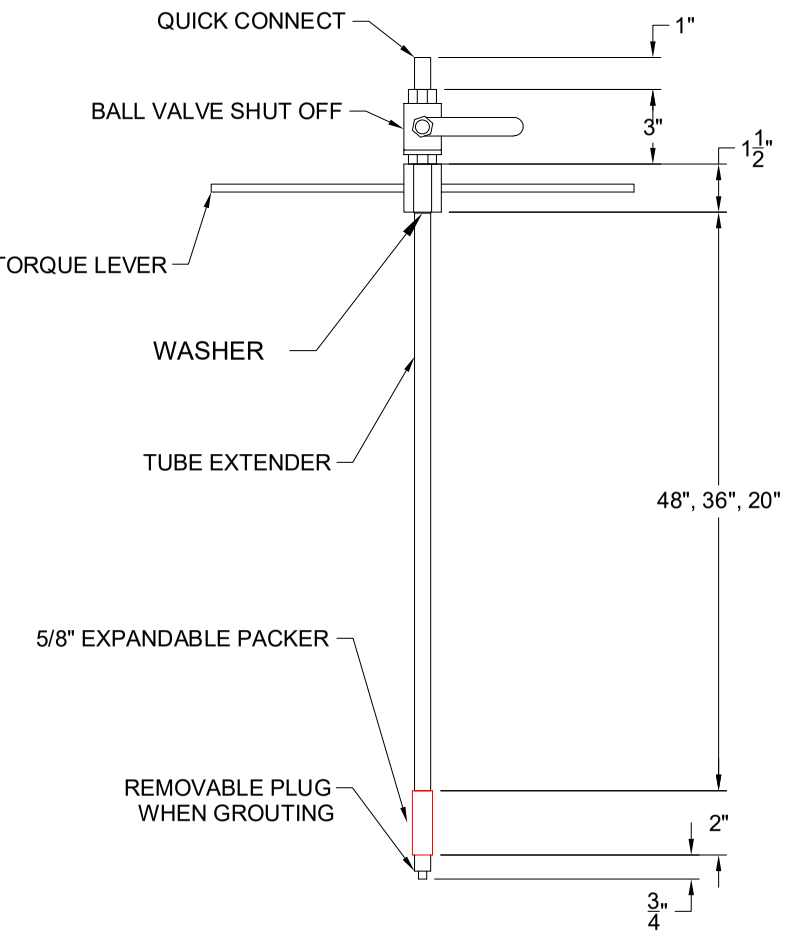


BALL VALVES, OPEN POSITION FOR CHEMICAL GROUT FLOW FROM GROUT PUMP

"E" ASSEMBLY



STRADDLE MECHANICAL PACKER



18" MECHANICAL PACKER

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

16 POLYACRYLATE GROUT, CRACK INJECTION
EXAMPLES OF GROUTING ACCESSORIES

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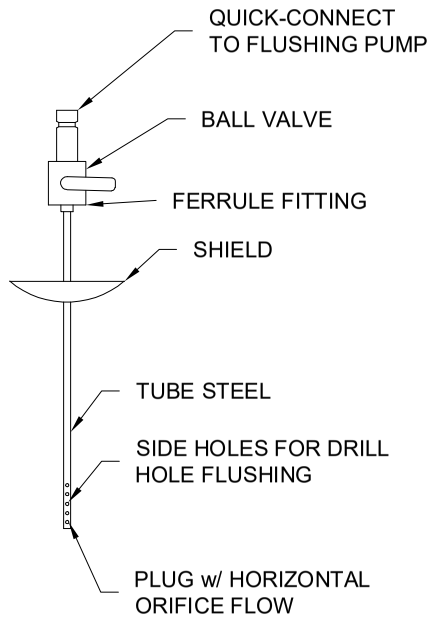
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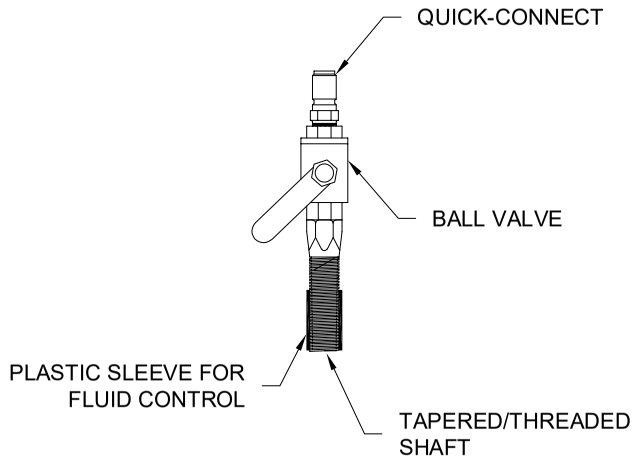
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RAYMOND ROAD CULVERT PIPE RESTORATION

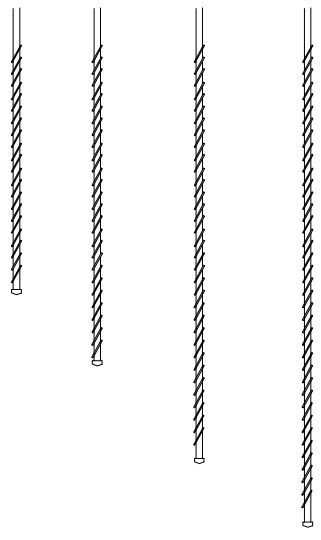
SHEET: 16E



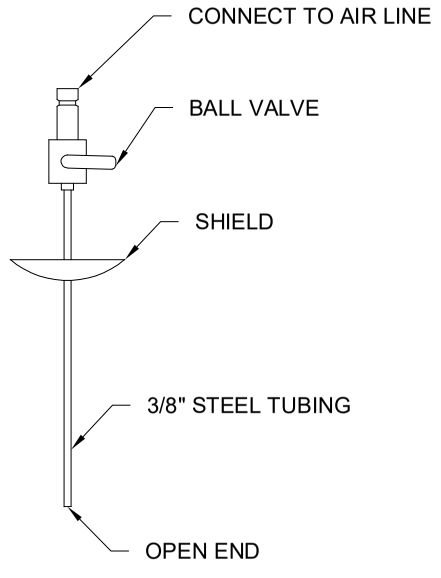
DRILL HOLE FLUSHING WAND



(TSBV) PACKER
TAPERED SHAFT, BALL VALVE (TSBV)



DRILL BITS OF VARIOUS LENGTHS & DIAMETERS



AIR FLUSHING WAND FOR
INITIAL DRILL HOLE CLEANING

17 POLYACRYLATE GROUT, CRACK INJECTION
EXAMPLES OF GROUTING ACCESSORIES

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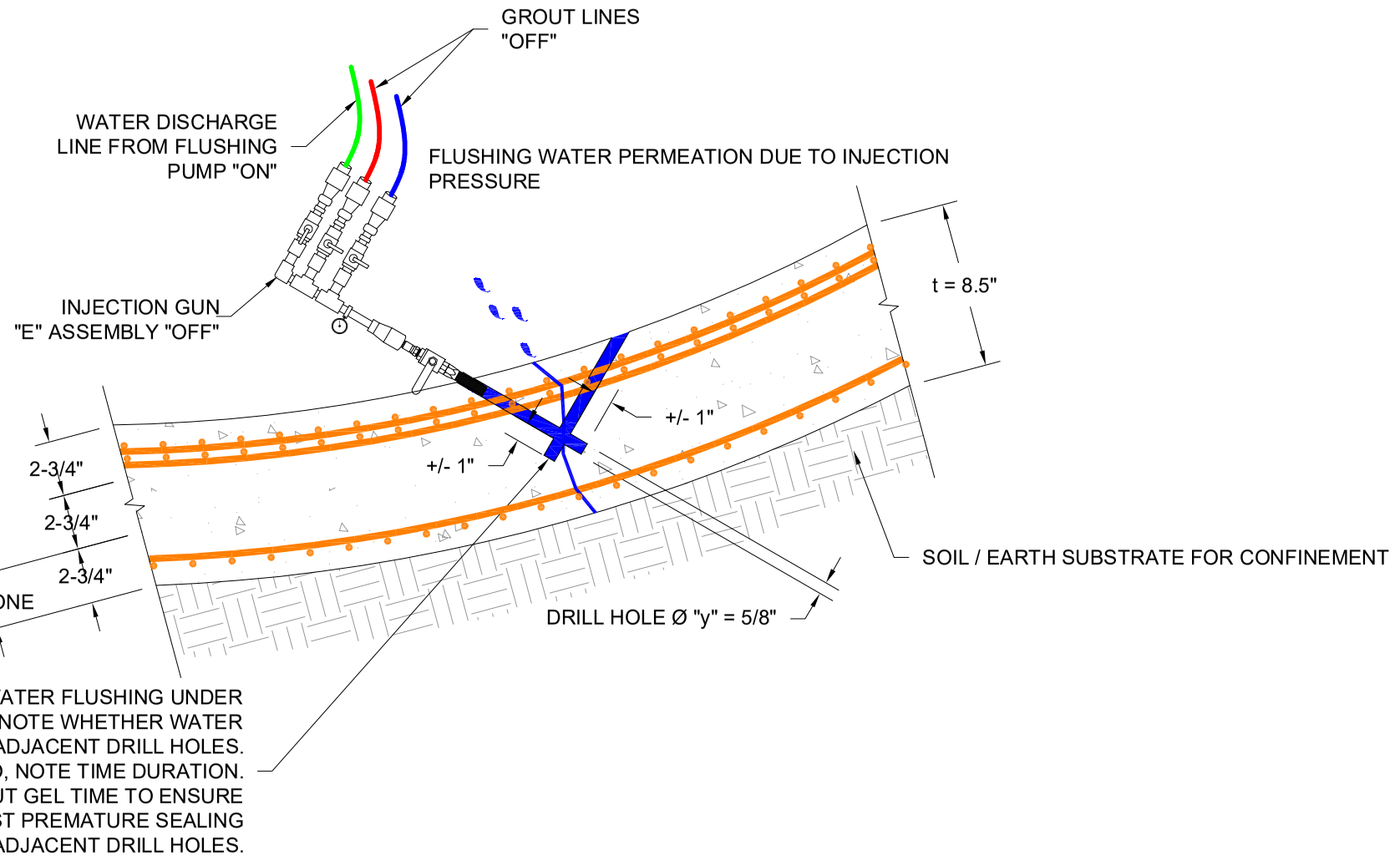
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 17E

1. PLACE BALL VALVE WITH QUICK-CONNECT, PACKER INTO DRILL HOLE AND TIGHTEN
2. ENSURE GOGGLES OR FACE-SHIELDS ARE IN PLACE
3. ATTACH "E" ASSEMBLY INJECTION HEAD TO PACKER, ENSURE PACKER IS SECURE
4. START INJECTING WATER FROM WATER FLUSHING PUMP AT 100 psig INTO CRACK, SEE SHEET 11
5. ENSURE WATER PERMEATES FROM CRACK 6 INCHES EACH DIRECTION CENTERED ON DRILL HOLE
6. IF WATER DOES NOT PERMEATE FROM CRACK, INCREASE PRESSURE IN 100 psig INCREMENTS, IF WATER FLUSHING PUMP PRESSURE BUILDS UP TO 700 psig, THE CRACK HAS NOT BEEN INTERCEPTED, EXCESSIVE PRESSURE MAY FRACK THE CONCRETE
7. STOP OPERATIONS, RELIEVE RESIDUAL WATER PRESSURE AND REMOVE INJECTION HEAD FROM PACKER, REMOVE PACKER AND RE-DRILL
8. DRILL DEEPER INTO CROSS-SECTION BECAUSE CRACK WAS NOT PROPERLY INTERCEPTED OR DRILLING DEBRIS HAVE PLUGGED INTERSECTION. REPEAT PROCESS UNTIL FLUSH WATER HAS PERMEATED FROM CRACK
9. HOLES THAT DO NOT ALLOW WATER PENETRATION SHALL BE MARKED AS "DEAD-HOLES"
10. ENSURE ALL DRILL HOLES PERMEATE FLUSHING WATER, CONTINUE FLUSHING WATER FOR 2 MINUTES

DEGREES OF WATER LEAKAGE:

TYPE 1: COLOR CHANGE (DARKER) DUE TO SURFACE MOISTURE CONTENT
TYPE 2: WET TO TOUCH, SURFACE DAMPNESS, NO SUSTAINED TRAIL
TYPE 3: WEEPS & SEEPAGE, SUSTAINED TRAIL OF WETNESS
TYPE 4: CONTINUOUS DRIPPING, VISIBLE SURFACE FLOW
TYPE 5: GUSHING FLOW FROM HYDROSTATIC PRESSURE



Key:

t = WALL / SLAB THICKNESS
1/3t = INTERCEPTION ZONE IN CRACK SECTION
x = MIN. DISTANCE FROM DRILL HOLE TO CRACK SHALL BE BETWEEN t/2 +/- (t/6)
⊖ = DRILL ANGLE TO SUBSTRATE SHALL TYPICALLY BE 45° AND CAN VARY +/- 15°
y = DRILL HOLE DIAMETER CAN BE 1/4", 3/8", 1/2", 5/8", AND 3/4"
t/2 = CENTERLINE OF ELEMENT
w = CRACK WIDTH
z = SPACING OF DRILL HOLES ALONG CRACK LENGTH SHALL BE BETWEEN t/2 to 2/3t

18 POLYACRYLATE GROUT, CRACK INJECTION

INJECTION INTO CRACKS / CRACK CLEANING PROCEDURE

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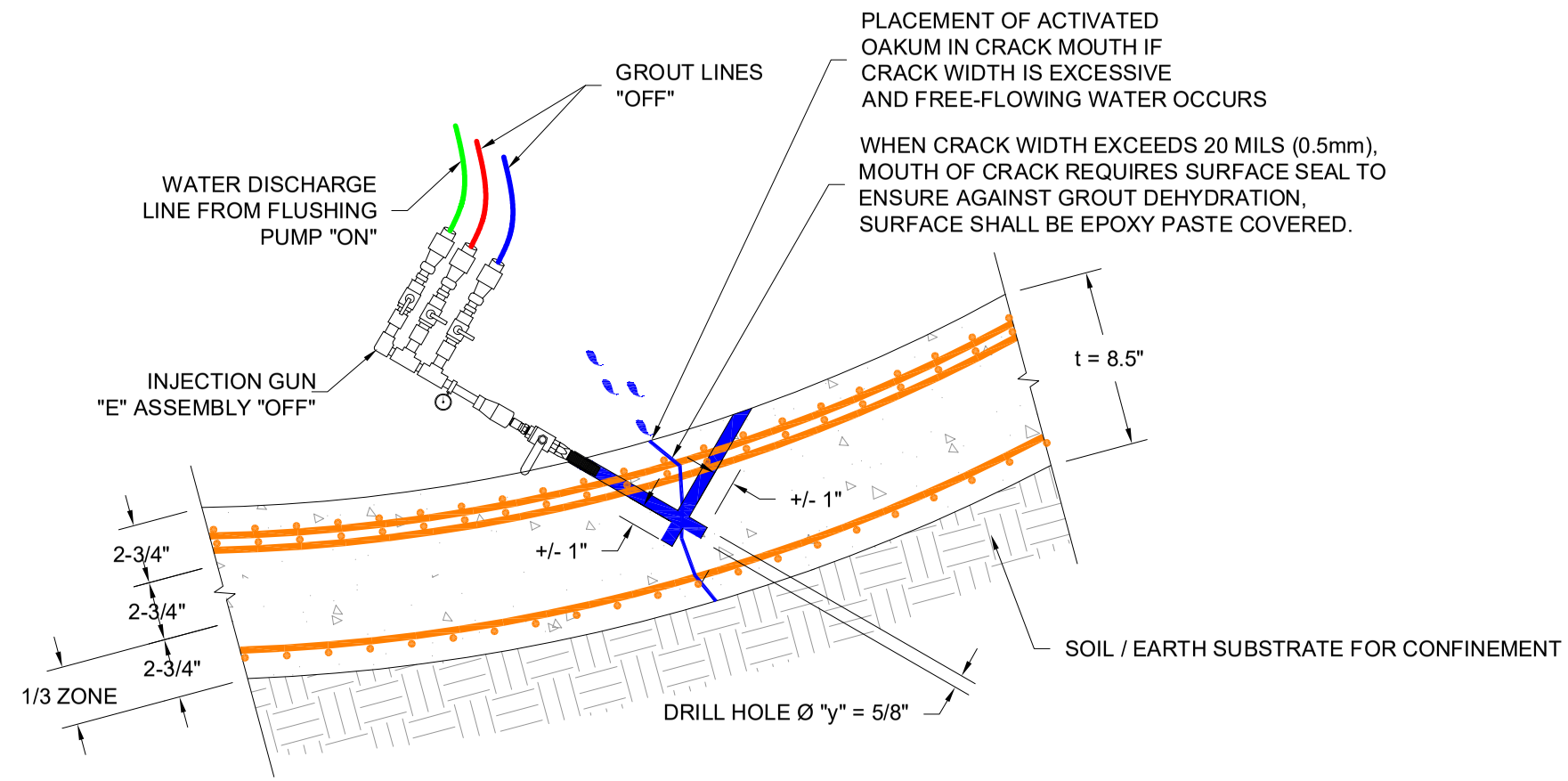
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 18E

1. WEAR PROPER PPE, ENSURE GOGGLES OR FACE-SHIELDS ARE CLEAR AND AVAILABLE FOR USE
2. IN CRACKS WHICH ARE WIDE ENOUGH TO ALLOW VISUALLY, FREE FLOWING WATER, PLACE UN-RAVELED OAKUM INTO MOUTH OF CRACK TO TEMPORARILY STOP THE UN-RESTRICTED FLOW OF WATER
3. OAKUM CAN BE SUPPLEMENTED WITH URETHANE OR POLYACRYLATE GROUT MIXTURE PRIOR TO PLACEMENT IN CRACK

DEGREES OF WATER LEAKAGE:

TYPE 1: COLOR CHANGE (DARKER) DUE TO SURFACE MOISTURE CONTENT
TYPE 2: WET TO TOUCH, SURFACE DAMPNESS, NO SUSTAINED TRAIL
TYPE 3: WEEPS & SEEPAGE, SUSTAINED TRAIL OF WETNESS
TYPE 4: CONTINUOUS DRIPPING, VISIBLE SURFACE FLOW
TYPE 5: GUSHING FLOW FROM HYDROSTATIC PRESSURE



19 POLYACRYLATE GROUT, CRACK INJECTION

INJECTION INTO CRACKS / CRACK CLEANING PROCEDURE
CRACK FLUSHING AND PREPERATION PROCEDURE

Key:

t = WALL / SLAB THICKNESS
1/3t = INTERCEPTION ZONE IN CRACK SECTION
x = MIN. DISTANCE FROM DRILL HOLE TO CRACK SHALL BE BETWEEN t/2 +/- (t/6)
⊖ = DRILL ANGLE TO SUBSTRATE SHALL TYPICALLY BE 45° AND CAN VARY +/- 15°
y = DRILL HOLE DIAMETER CAN BE 1/4", 3/8", 1/2", 5/8", AND 3/4"
t/2 = CENTERLINE OF ELEMENT
w = CRACK WIDTH
z = SPACING OF DRILL HOLES ALONG CRACK LENGTH SHALL BE BETWEEN t/2 to 2/3t

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Date: 1/9/2020 Registration No: 23802-6

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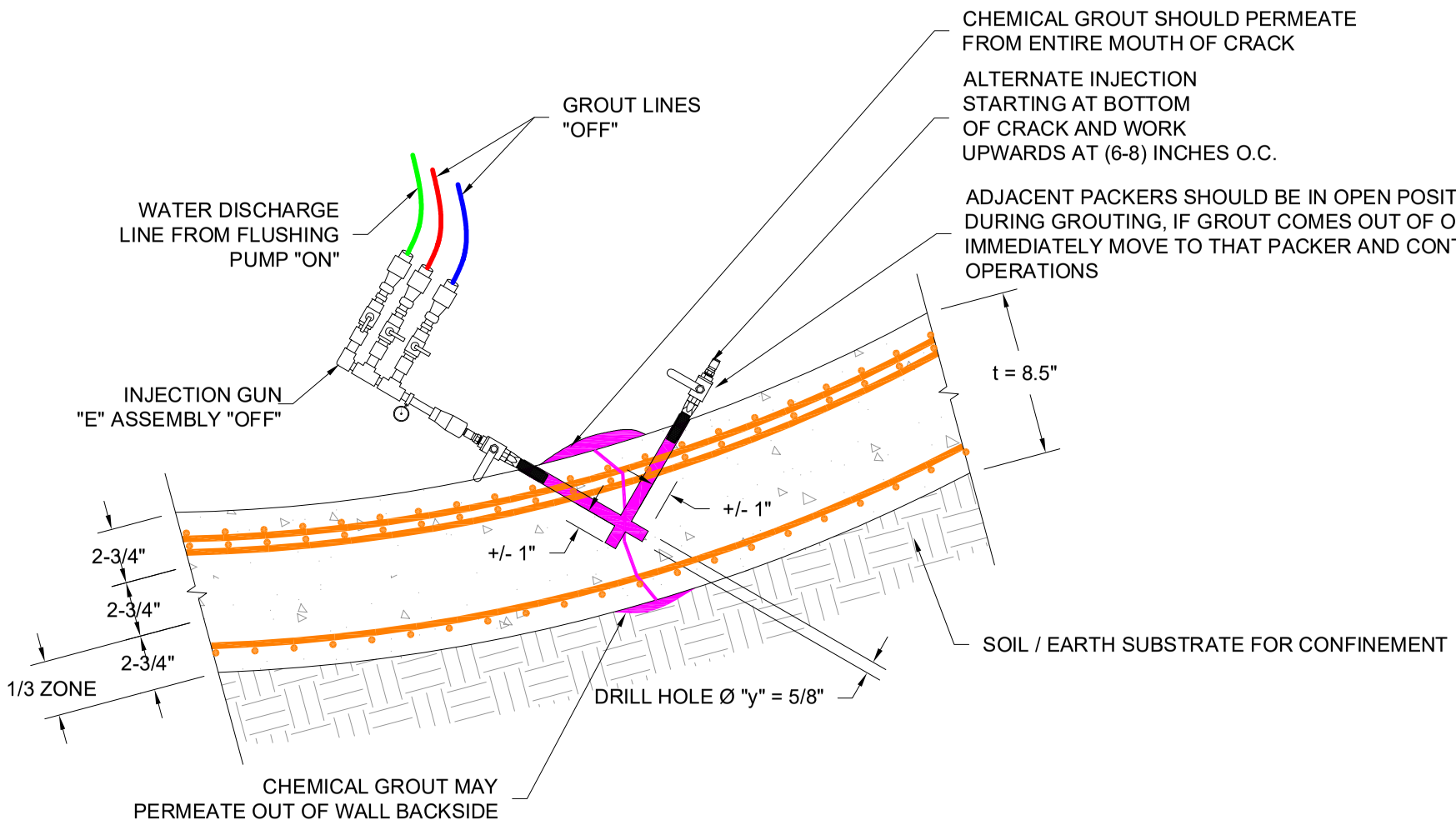
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 19E

1. AFTER CRACK FLUSHING IS COMPLETED, SEE SHEET 11 FOR CHEMICAL GROUT SYSTEM (CGS) PRESSURE INJECTION
2. WEAR PROPER PERSONAL PROTECTIVE EQUIPMENT, ENSURE GOGGLES OR FACE-SHIELDS ARE CLEAR AND AVAILABLE FOR USE
3. ATTACH INJECTION HEAD ON PACKER AT LOWEST POINT ON CRACK LENGTH
4. START CHEMICAL GROUT PRESSURE INJECTION PUMP AT 200 psig, IF SAID PUMP CEASES TO DISPLACE PISTONS, INCREASE PRESSURE IN 100 psi INCREMENTS TILL CHEMICAL GROUT FLOW RESUMES, SEE SHEET 11 AND SIMILAR
5. DO NOT EXCEED 700 psig
6. CONTINUE PUMPING TILL UNREACTED CHEMICAL GROUT FLOWS 6" ABOVE AND BELOW DRILL HOLE MIDPOINT OR SIMILAR
7. ENSURE ITEM # 5 DIRECTLY ABOVE OCCURS PRIOR TO THE CHEMICAL GROUT GEL-TIME MEASURED BY THE CUP TEST, SEE SHEET 12 AND 13
8. ALWAYS FLUSH STATIC MIXER ON INJECTION HEAD PRIOR TO GEL-TIME MEASURED FROM CUP TEST
9. UPON COMPLETION OF #5 ABOVE, DISCONNECT "E" ASSEMBLY FROM PACKER AND CONTINUE UPWARDS ON CRACK, PACKER-TO-PACKER
10. SEE SHEET 14-15 FOR GROUT PUMP CARE

DEGREES OF WATER LEAKAGE:

TYPE 1: COLOR CHANGE (DARKER) DUE TO SURFACE MOISTURE CONTENT
TYPE 2: WET TO TOUCH, SURFACE DAMPNESS, NO SUSTAINED TRAIL
TYPE 3: WEEPS & SEEPAGE, SUSTAINED TRAIL OF WETNESS
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TYPE 5: GUSHING FLOW FROM HYDROSTATIC PRESSURE



Key:

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20 POLYACRYLATE GROUT, CRACK INJECTION

INJECTION INTO CRACKS / CRACK CLEANING PROCEDURE
CRACK INJECTION PROCEDURE

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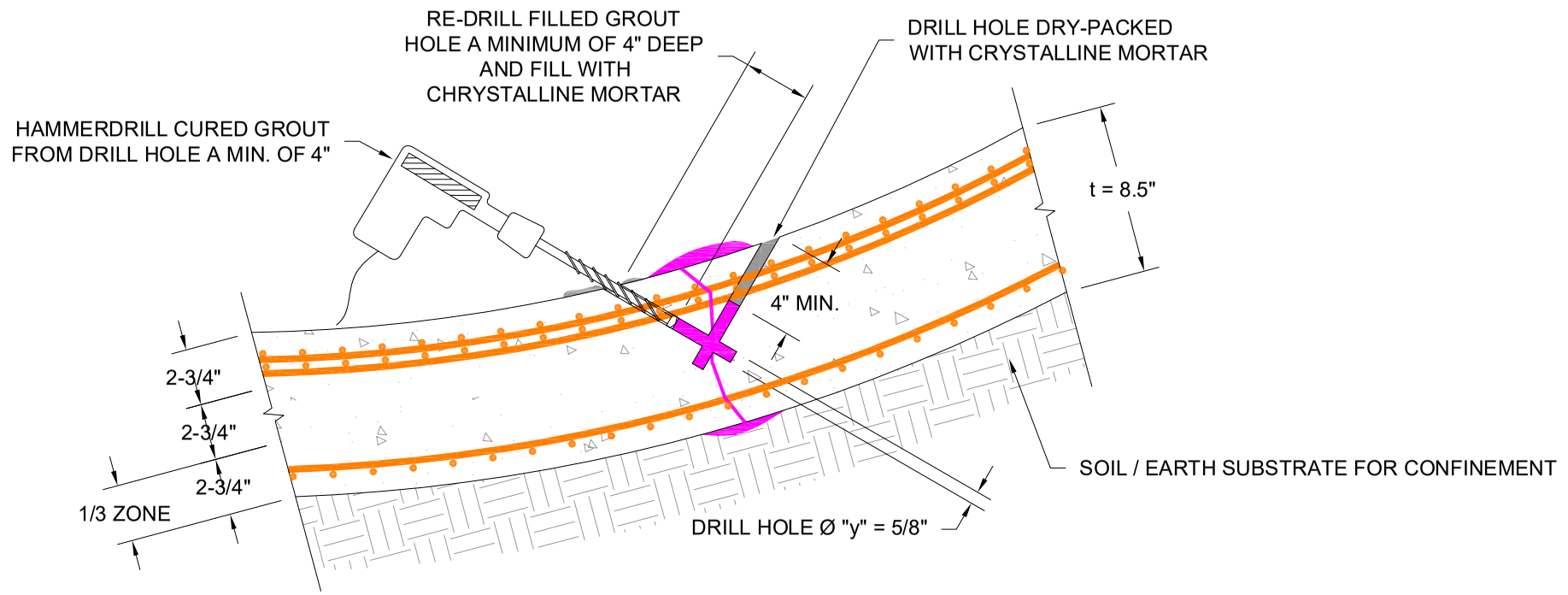
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RAYMOND ROAD CULVERT PIPE RESTORATION

1. AFTER COMPLETION OF CHEMICAL GROUT SYSTEM (CGS) PRESSURE INJECTION AND SETTING/GELLING OF CHEMICAL GROUT, REMOVE MECHANICAL PACKER FROM DRILL HOLE
2. RE-DRILL HOLE TO RID CURED GROUT TO A MINIMUM OF 4 INCHES, FLUSH & RINSE WITH CLEAN WATER FROM FLUSHING PUMP
3. MIX BATCH OF CRYSTALLINE MORTAR AND DRY-PACK DOWN DRILL HOLE, IN ACCORDANCE WITH SITE PROCEDURES
4. FLUSH SURFACE WITH MARGIN TROWEL IF EXCESSIVE MORTAR EXISTS

DEGREES OF WATER LEAKAGE:

TYPE 1: COLOR CHANGE (DARKER) DUE TO SURFACE MOISTURE CONTENT
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TYPE 3: WEEPS & SEEPAGE, SUSTAINED TRAIL OF WETNESS
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TYPE 5: GUSHING FLOW FROM HYDROSTATIC PRESSURE



21 POLYACRYLATE GROUT, CRACK INJECTION

INJECTION INTO CRACKS / DRILL HOLE RESTORATION

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t/2 = CENTERLINE OF ELEMENT
w = CRACK WIDTH
z = SPACING OF DRILL HOLES ALONG CRACK LENGTH SHALL BE BETWEEN t/2 to 2/3t

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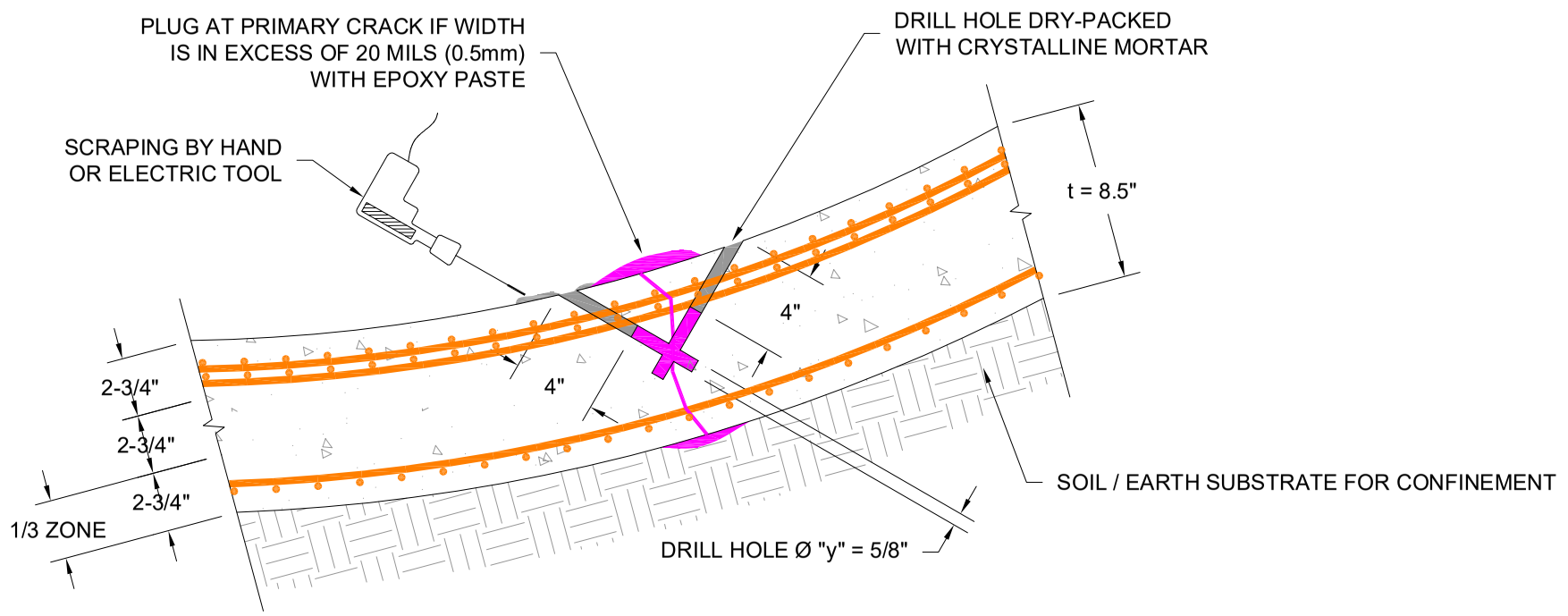
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 21E

1. SCRAPE, CHIP OR GRIND SURFACE CLEAN AND FLUSH PRIOR TO DE-MOBILIZATION
2. CONCRETE IS MONOLITHIC AGAIN

DEGREES OF WATER LEAKAGE:

TYPE 1: COLOR CHANGE (DARKER) DUE TO SURFACE MOISTURE CONTENT
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22 POLYACRYLATE GROUT, CRACK INJECTION

INJECTION INTO CRACKS / DRILL HOLE RESTORATION

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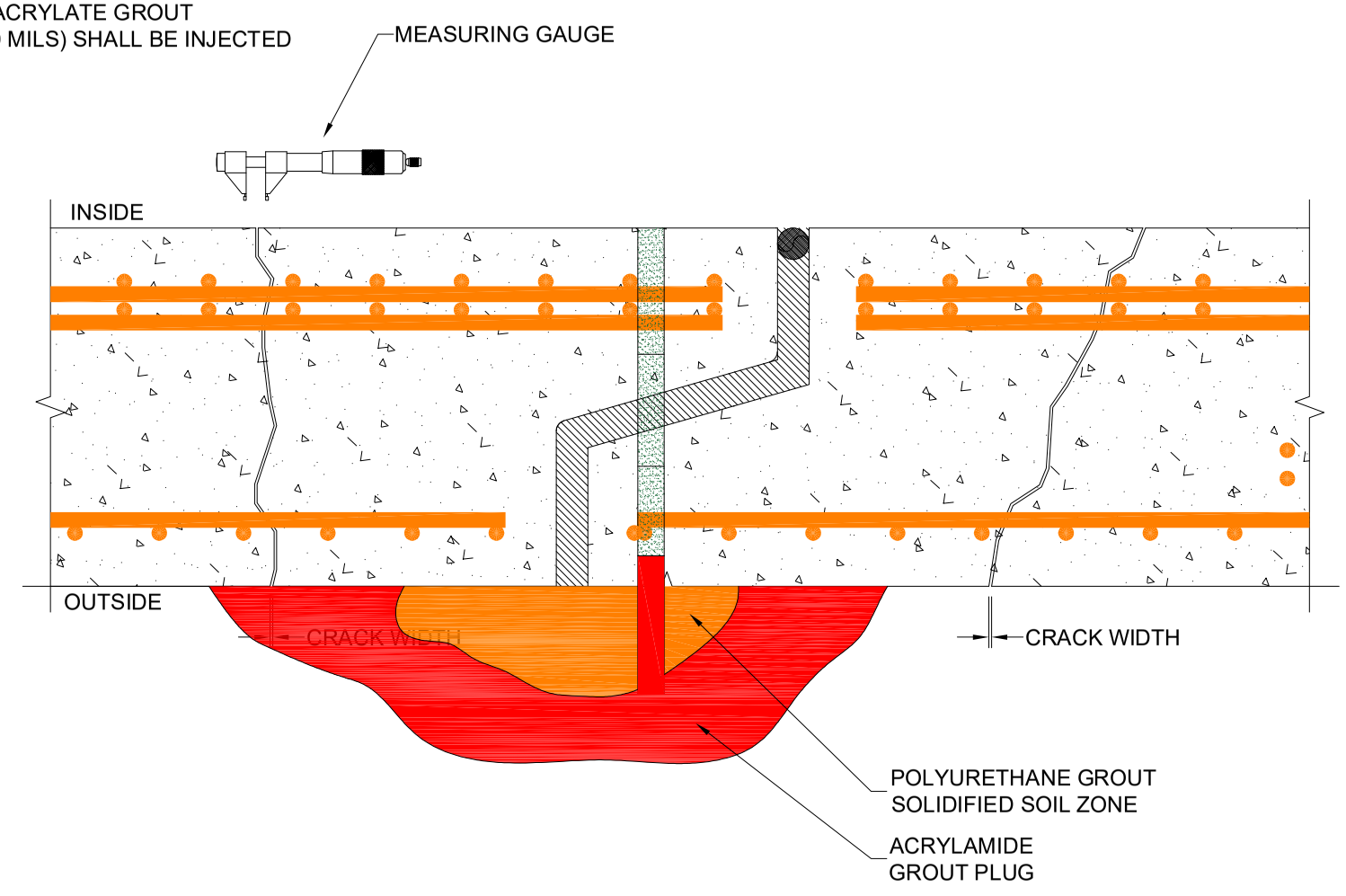
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 22E

GENERAL CONDITIONS:

1. COORDINATE SAFETY PLAN TO INCLUDE MANAGEMENT OF MANCHETTE TOPS TO AVOID TRIP HAZARDS TO TRADESMEN
2. COORDINATE ACCESS/EGREE PLAN IN CASE OF HIGH WATER, EXCESS CARBON DIOXIDE, LACK OF LIGHTING AND/OR OTHER ISSUES THAT MAY REQUIRE UNPLANNED EVACUATION OF CULVERT PIPE
3. COORDINATE WORKING TIMES TO ENSURE STORM WATER DRAINAGE DOES NOT INTERFERE WITH GROUTING OPERATIONS BEYOND MANAGED WATER RE-ROUTING
4. ENSURE PROJECT TEAM IS COORDINATED WITH WEATHER FORECASTS AND CURRENT CONDITIONS
5. ENSURE WATER DIVERSION PLAN IS APPROVED BY OWNER
6. FOLLOW ALL OSHA REQUIREMENTS FOR CONFINED SPACE
7. ENSURE:
   - 7.1. PROPER & ADEQUATE LIGHTING & ELECTRICAL SUPPLY
   - 7.2. PROPER & ADEQUATE FRESH AIR-SUPPLY
   - 7.3. PROPER & ADEQUATE AIR QUALITY MONITORING
   - 7.4. PROPER & ADEQUATE EYE WASH STATIONS ARE SETUP
8. IDENTIFY ALL BURIED UTILITIES WITHIN IMMEDIATE GROUT ZONE AREA.
9. IDENTIFY STORM OR SANITARY SEWER PIPES WITHIN 10 FEET OF GROUT ZONE, AND ESTABLISH SOME CRITERIA TO MONITOR EXISTING PIPING DURING CHEMICAL GROUTING TO ENSURE NO STRAY GROUT MIGRATION OCCURS.

1. MEASURE WIDTH OF ALL CRACKS:
2. NOTE THE FOLLOWING:
   - 2.1. CRACKS LESS THAN 0.021 INCHES (21 MILS) SHALL BE SURFACE TREATED WITH CRYSTALLINE WATERPROOFING
   - 2.2. CRACKS GREATER THAN 0.020 INCHES AND LESS THAN 0.040 INCHES (40 MILS) SHALL BE INJECTED WITH POLYACRYLATE GROUT
   - 2.3. CRACKS GREATER THAN 0.040 INCHES (40 MILS) SHALL BE INJECTED WITH EPOXY RESIN



1 EPOXY RESIN GROUT, CRACK INJECTION

MEASURING CRACK WIDTHS IN EXCESS OF 40 MILS (0.040")

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GENERAL NOTES:			
1. STEEL REINFORCING VARIES AT LOCATIONS IN CULVERT PIPE.			

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Date: 1/9/2020 Registration No: 23802-6

By: Brent Anderson

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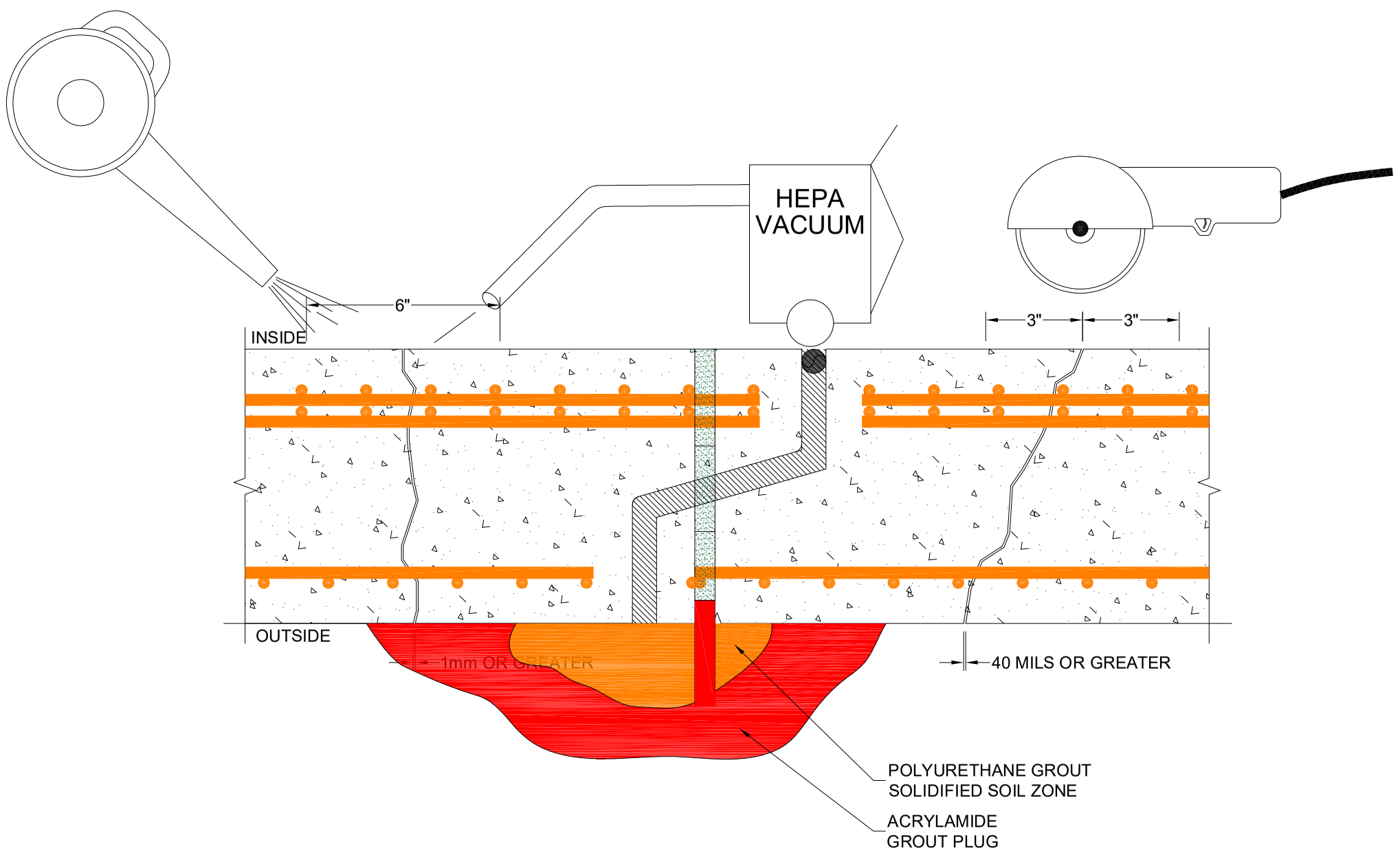
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 1F

1. MEASURE WIDTH OF ALL CRACKS:
2. NOTE THE FOLLOWING:
   2.1. CRACKS LESS THAN 0.021 INCHES (21 MILS) SHALL BE SURFACE TREATED WITH CRYSTALLINE WATERPROOFING
   2.2. CRACKS GREATER THAN 0.020 INCHES AND LESS THAN 0.040 INCHES (40 MILS) SHALL BE INJECTED WITH POLYACRYLATE GROUT
   2.3. CRACKS GREATER THAN 0.040 INCHES (40 MILS) SHALL BE INJECTED WITH EPOXY RESIN



2 EPOXY RESIN GROUT, CRACK INJECTION
SURFACE PREPERATION

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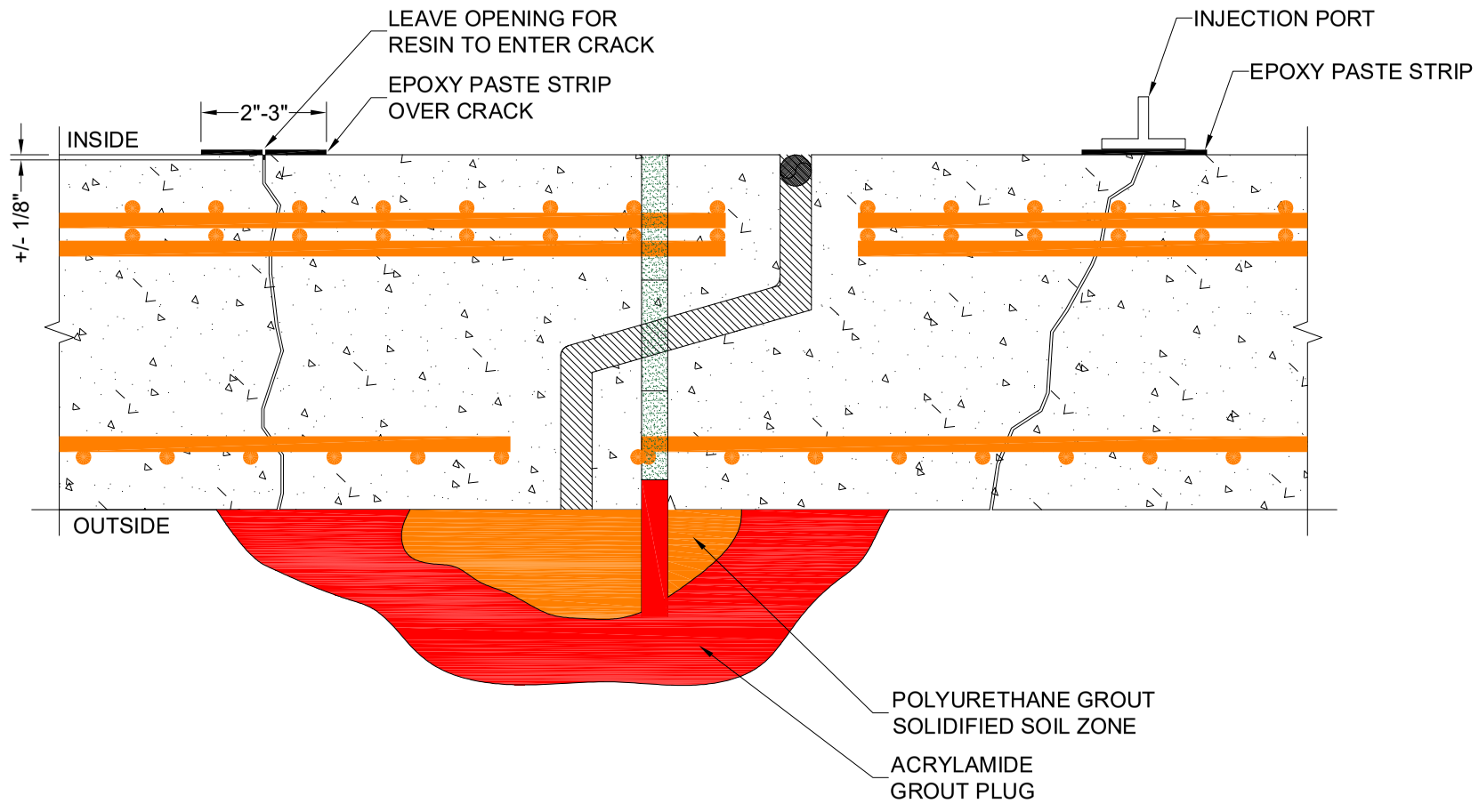
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 2F

1. CENTER EPOXY INJECTION PORTS OVER CONCRETE CRACKS AT 6"-8" O.C.
2. PLACE EPOXY PASTE OVER CRACK APPROXIMATELY 2"-3" WIDE AND 1/8" THICK



3 EPOXY RESIN GROUT, CRACK INJECTION

PLACEMENT OF EPOXY ADHESIVE FOR PORTS

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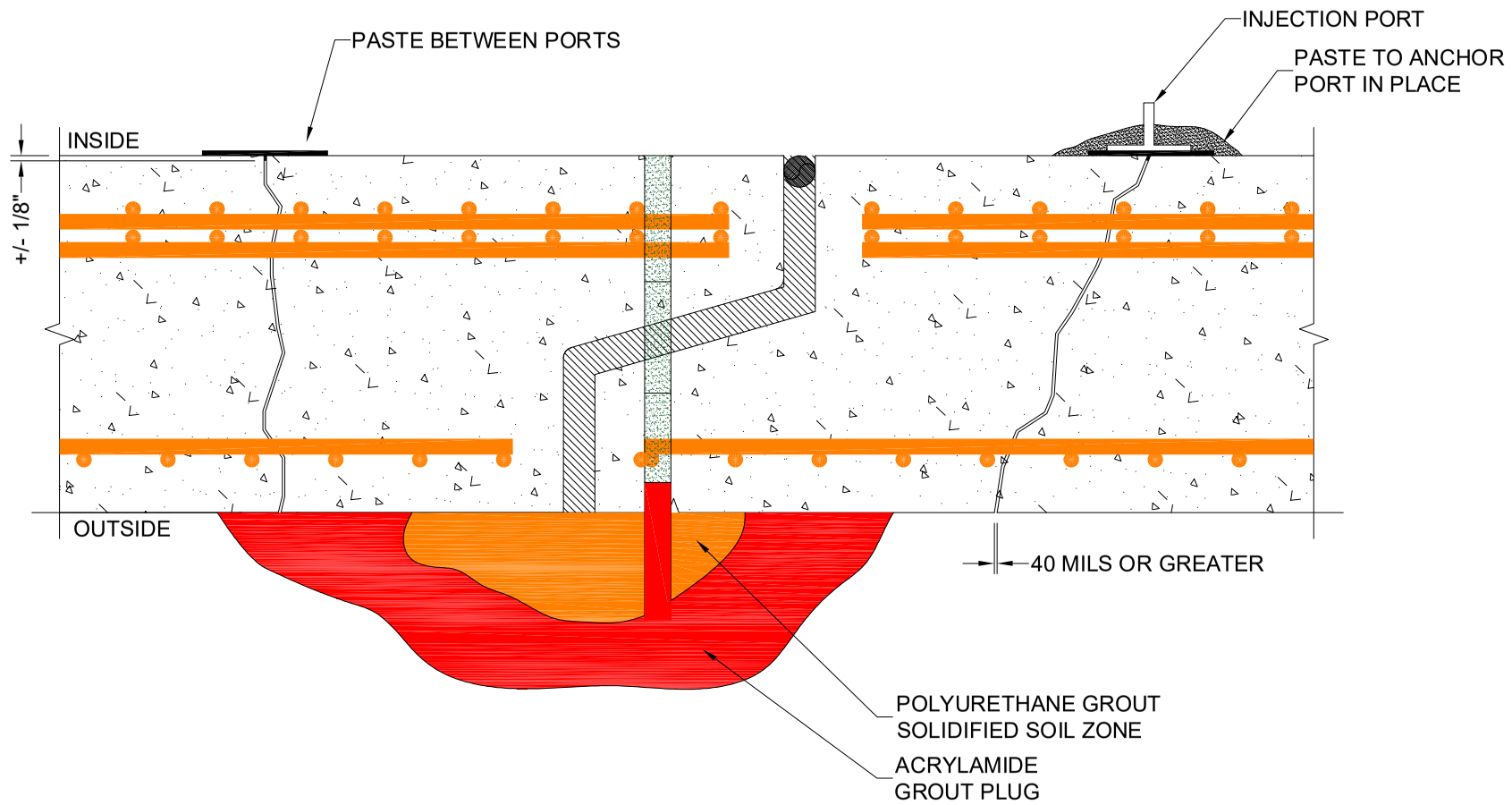
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 3F

1. PLACE EPOXY PASTE OVER PORT SIDES TO ENSURE AGAINST LEAKAGE.



4 EPOXY RESIN GROUT, CRACK INJECTION

EPOXY PASTE STRIP TO SEAL CRACK MOUTH

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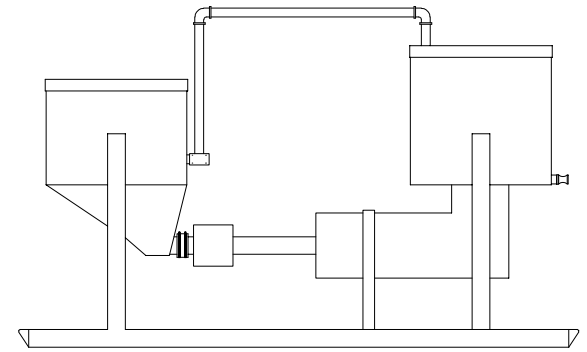
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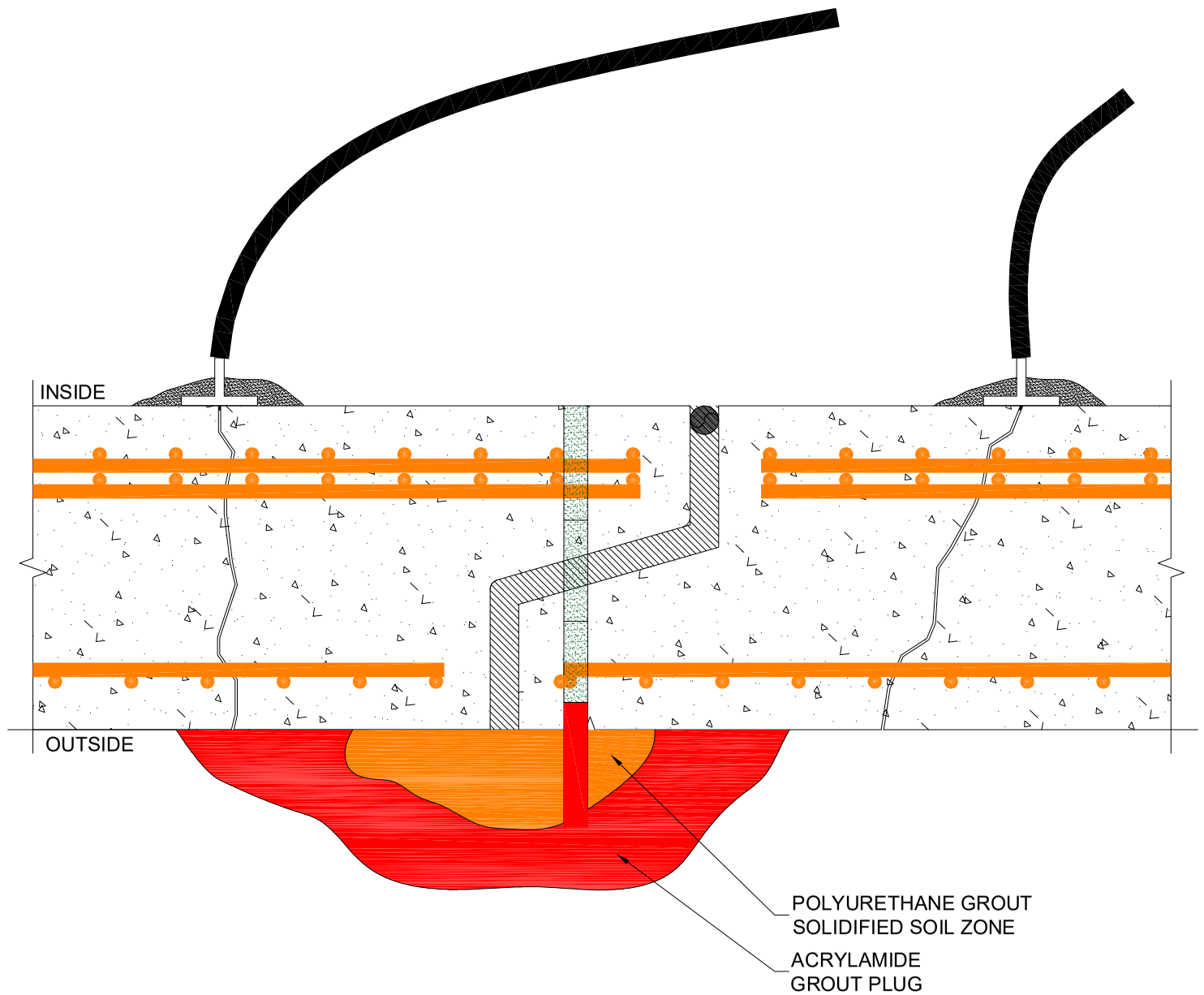
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 4F

1. ALLOW EPOXY PASTE TO CURE AND HARDEN
2. MIX EPOXY RESIN COMPONENTS "A" & "B" IN PUMP WITH PROPORTIONER
3. PUMP RESIN AT +/- 50 psig AND AT 1/4 GAL PER MINUTE OR LESS
4. WHEN EPOXY FLOWS FROM ADJACENT PORT A MOVE TO NEXT IN LINE
5. CRIMP PORTS AFTER INJECTION

COLLOIDAL MIXER





5 EPOXY RESIN GROUT, CRACK INJECTION

EPOXY RESIN INJECTION

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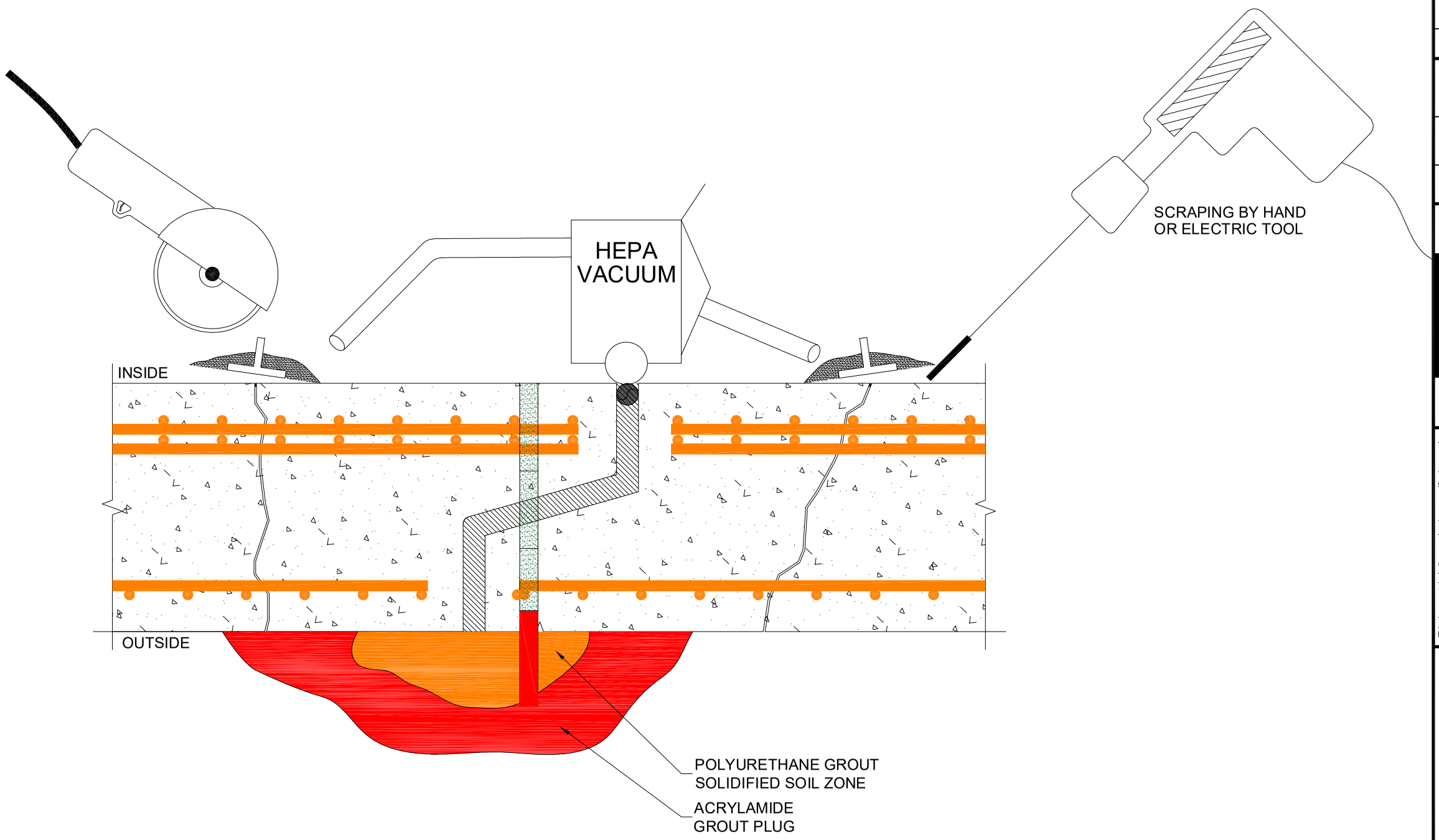
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 5F

1. CHIP AND / OR GRIND EPOXY INJECTION PORTS FROM SURFACE



6 EPOXY RESIN GROUT, CRACK INJECTION
REMOVAL OF SURFACE PORTS

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Date: 1/9/2020 Registration No: 23802-6

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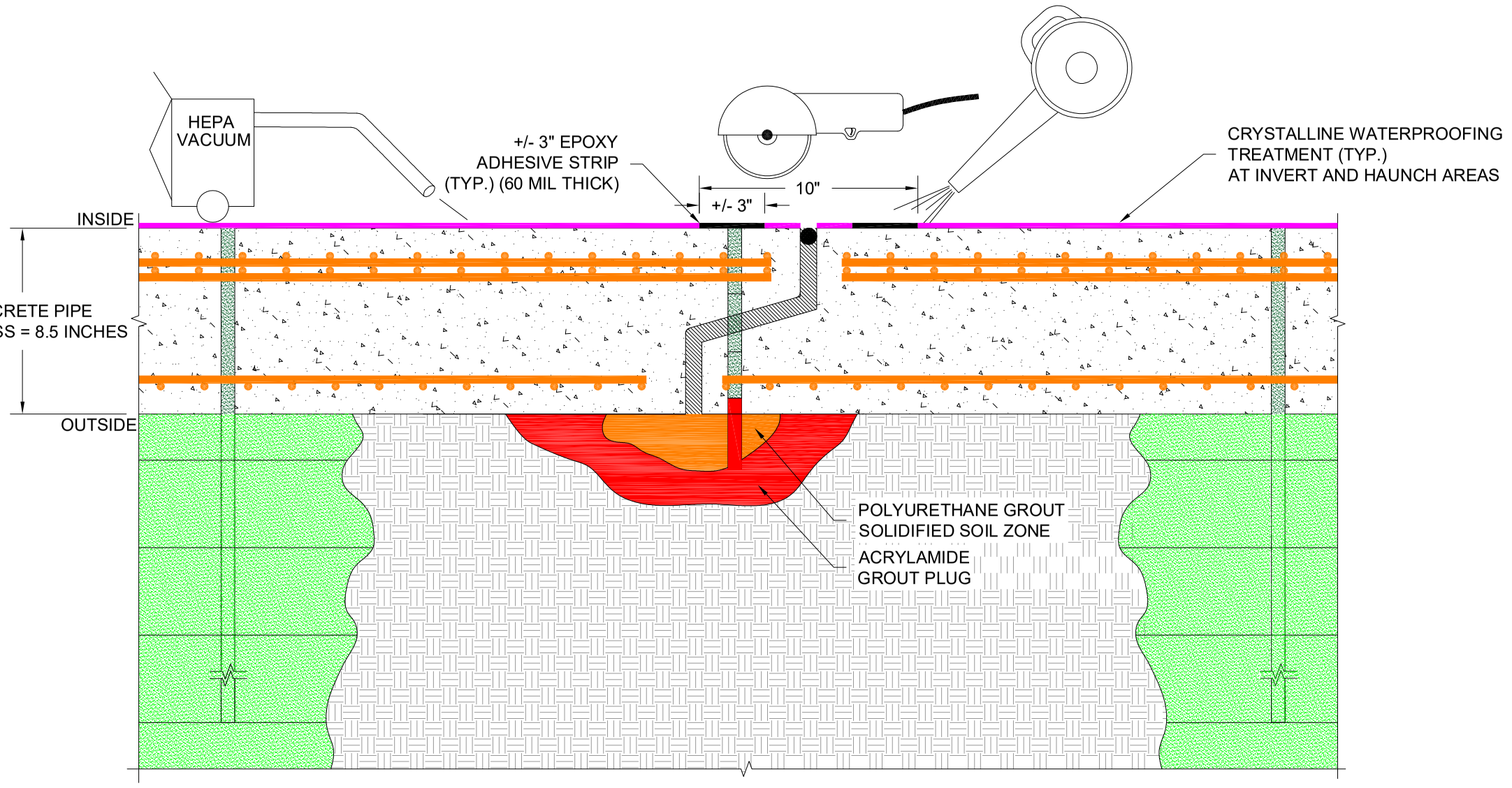
RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 6F

1. CLEAN AND DRY SUBSTRATE AT PIPE FLANGES.
2. REMOVE ANY EXCESS ASPHALT DEBRIS IN 10 INCH WIDE STRIP ZONE.
3. APPLY EPOXY ADHESIVE IN +/- 3" WIDE STRIPS ON EACH SIDE OF JOINT.

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GENERAL NOTES:			
1. STEEL REINFORCING VARIES AT LOCATIONS IN CULVERT PIPE.			



1 STRIP SEALS, AT JOINTS IN EXCESS OF 1.5 INCHES
SURFACE PREPERATION, APPLICATION OF EPOXY ADHESIVE

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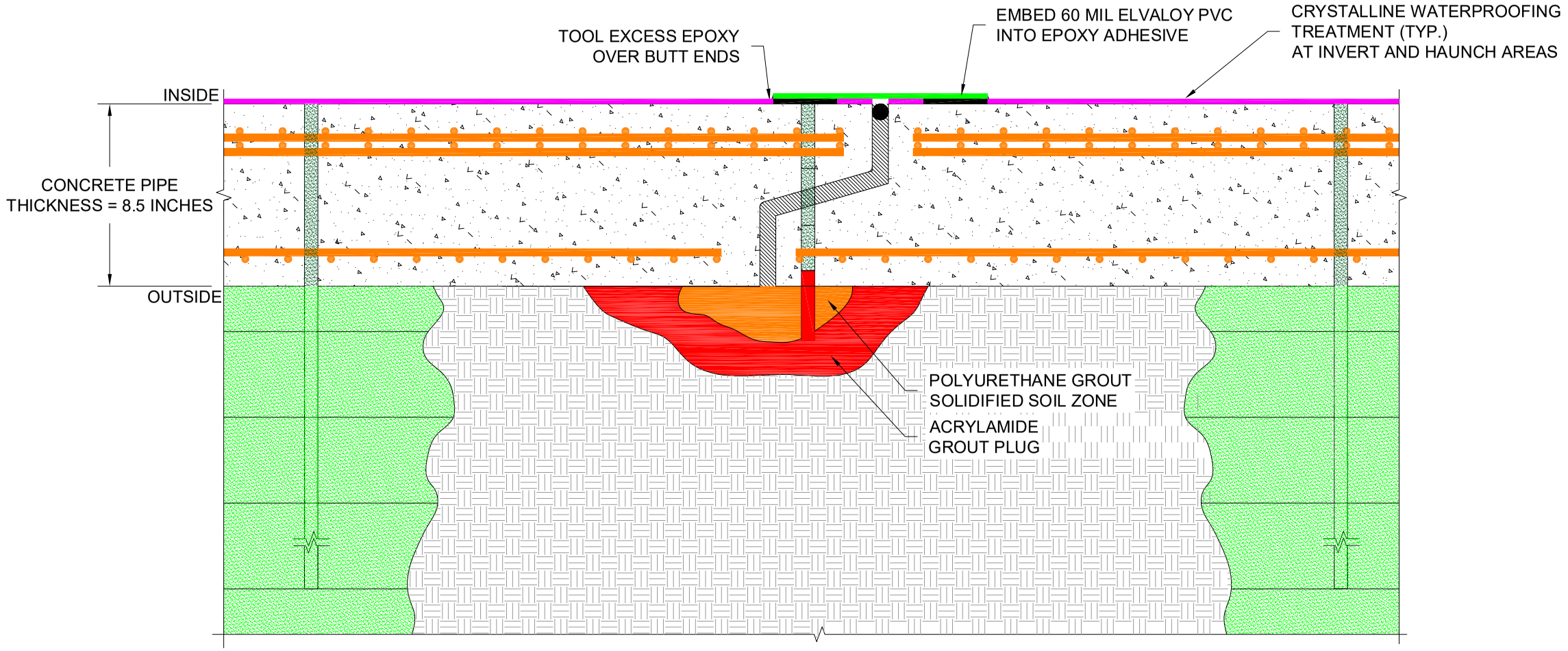
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 1G

1. INSTALL 60mil ELVALOY PVC STRIP INTO EPOXY ADHESIVE
2. PRESS 10 INCH WIDE, 60 mil, ELVALOY PVC STRIP INTO EPOXY ADHESIVE
3. ENSURE 10 INCH WIDE SHEET IS UNIFORMLY EMBEDDED, AND END LAPPED ONTO ITSELF A MINIMUM OF 4 INCHES
4. END LAPS SHALL BE WITHIN 2 LINEAL FEET OF TUNNEL CROWN
5. HEAT WELD LAP
6. TOOL EXCESS EPOXY OVER EDGE OF MEMBRANE



2 STRIP SEALS, AT JOINTS IN EXCESS OF 1.5 INCHES
MEMBRANE EMBEDMENT INTO EPOXY ADHESIVE

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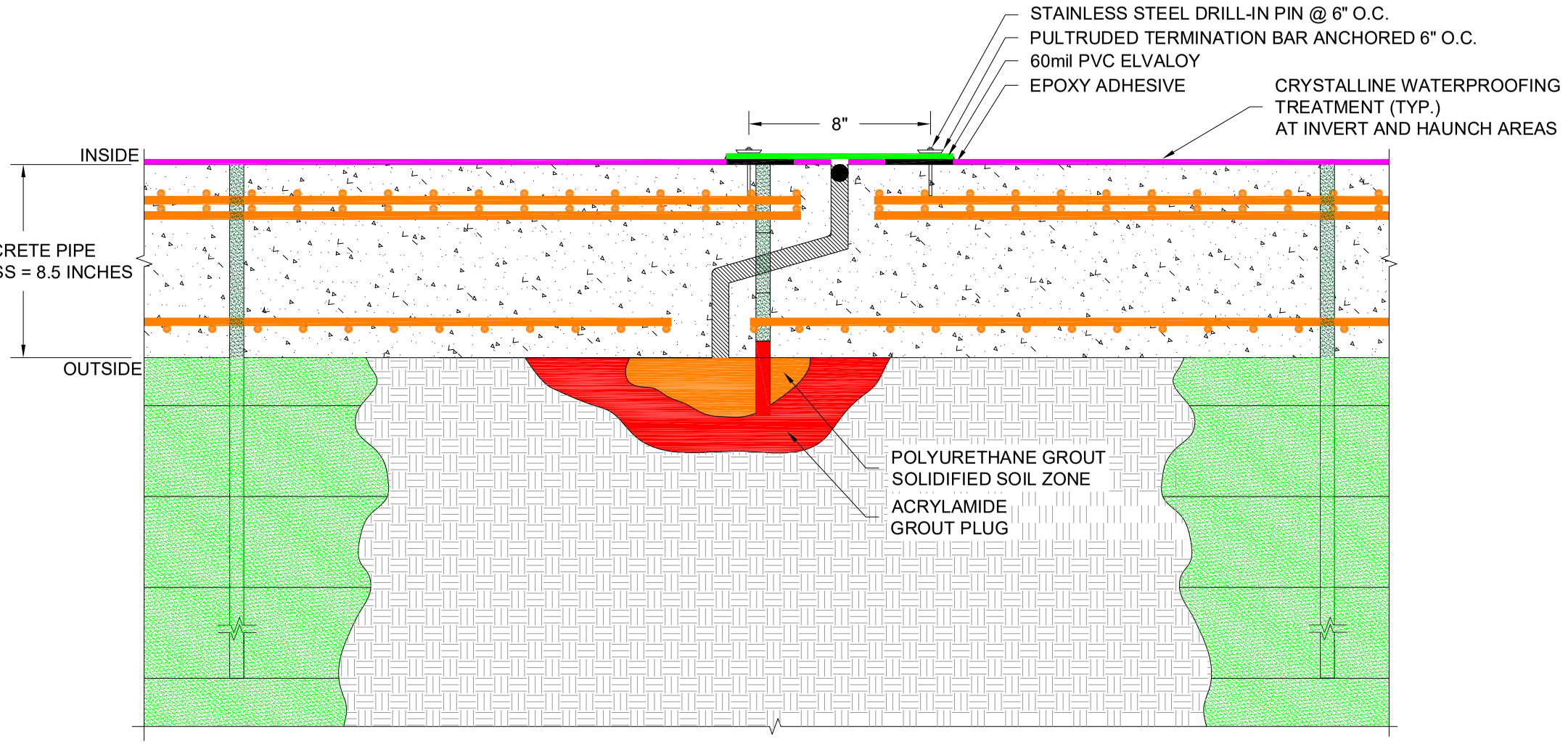
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 2G

1. INSTALL TERMINATION BAR (STAINLESS OR PULTRUDED FIBERGLASS) AT 6" O.C. DRILL -IN PINS.



3 STRIP SEALS, AT JOINTS IN EXCESS OF 1.5 INCHES
TERMINATION BAR APPLICATION

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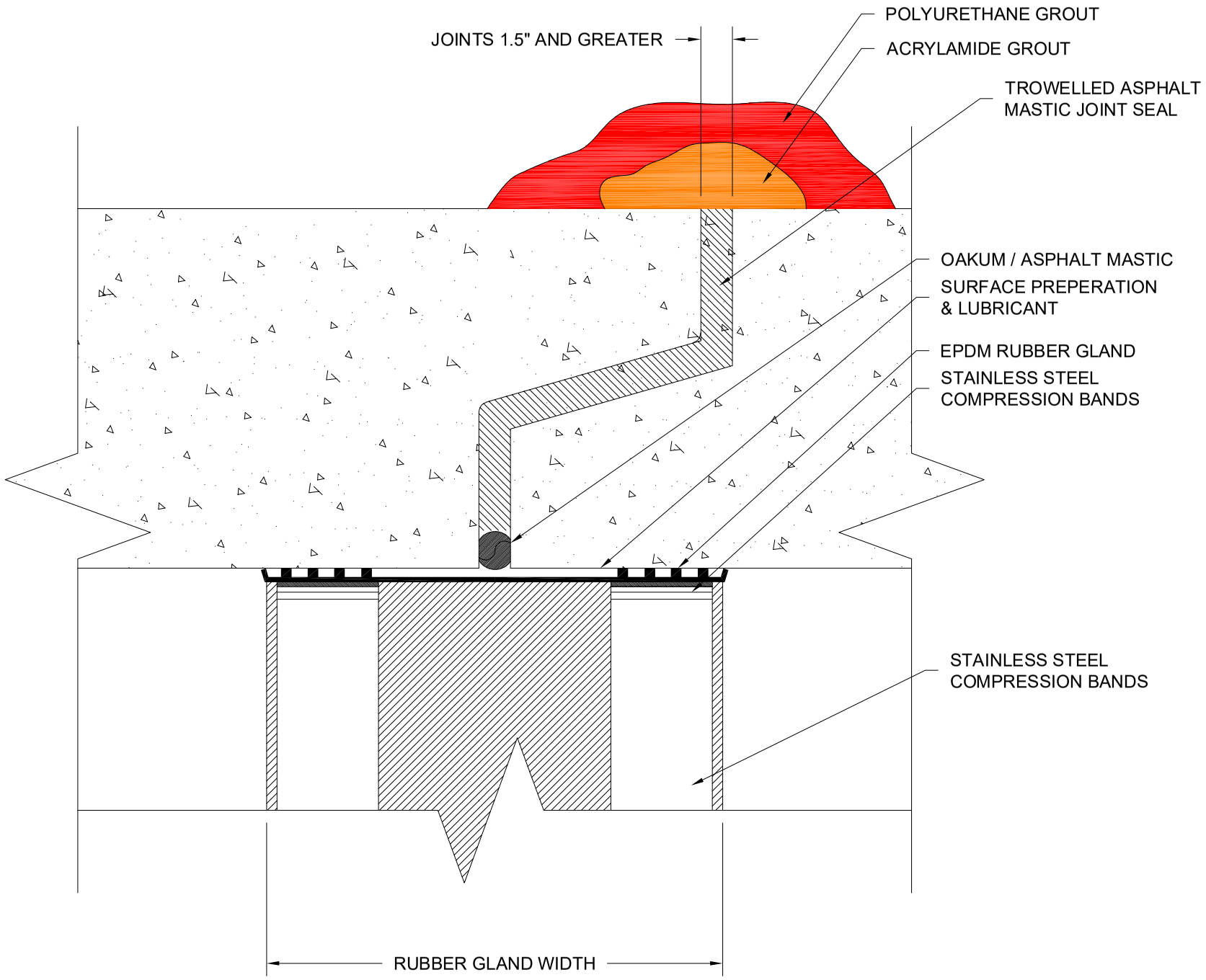
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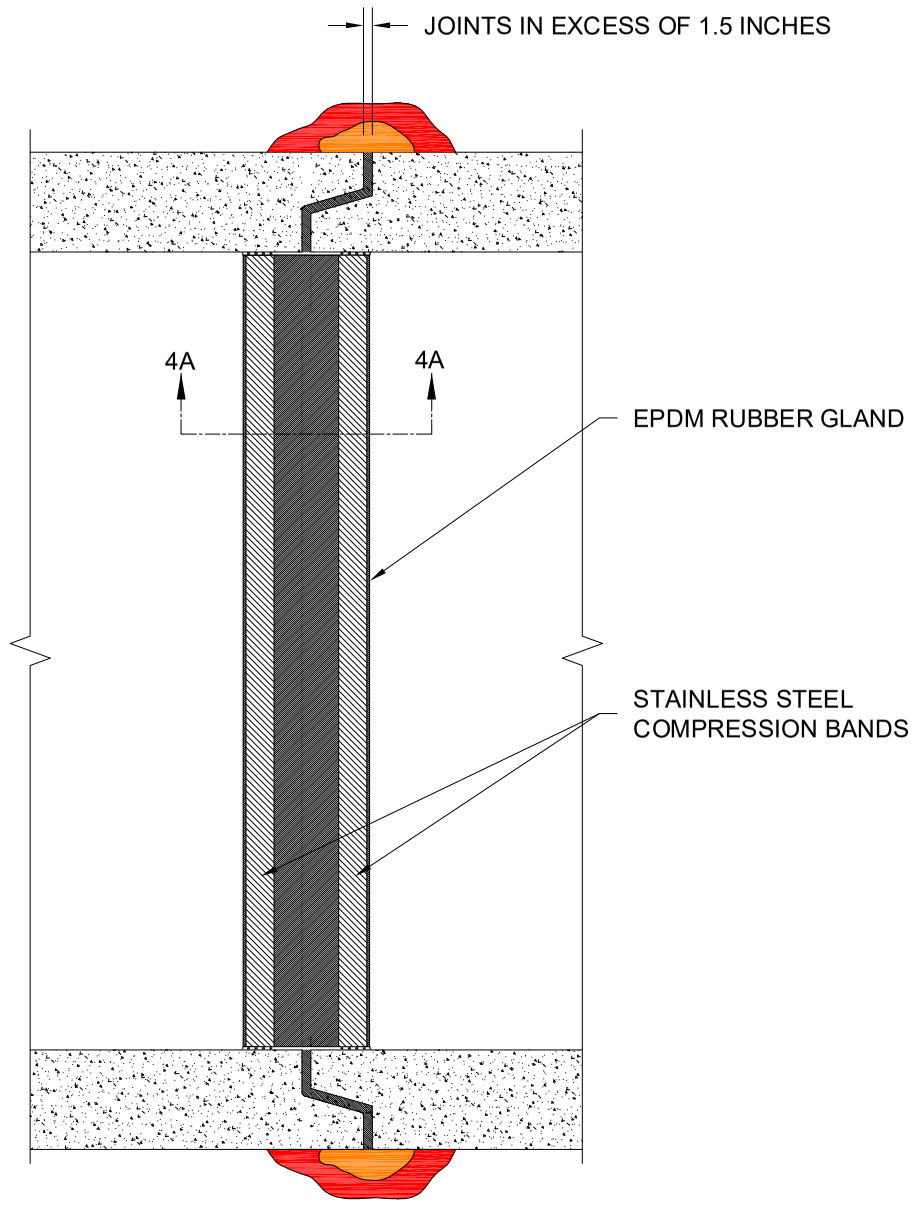
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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 3G



4A SECTION OF INTERIOR JOINT SEAL
INTERIOR JOINT SEAL COMPONENTS



4B ELEVATION OF INTERIOR JOINT SEAL
INTERNAL JOINT SEALING SYSTEM (STANDARD)

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RAYMOND ROAD CULVERT PIPE RESTORATION

SHEET: 4G

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March 4, 2020

VIA EMAIL

Via Email: Karla.Knorr@dot.wi.gov
Karla Knorr, Project Supervisor
WisDOT Southwest Region
2101 Wright Street
Madison, WI 53704-2583

Dear Ms. Knorr:

Thank you for your comments and questions submitted on February 13, 2020. On February 14, 2020, we submitted them to Brent Nelson (CNA) and Brent Anderson for their review. Based upon the input and opinions we received from Brent Anderson and Brent Nelson, the following is our response to the Department's questions:

BPA Plan Comments; (We assume this refers to "BDA"):

1. The specifications are out of order with respect to the table of contents

   RESPONSE:

   The Table of Contents lists the various series drawings in order (left column) with the appropriate page numbers. The left column lists the associated specifications to the various series drawings with no page numbers. Normally, specification documents are listed by their sequential numbering.

2. Footers in the specifications do not match the table of contents or the section headings

   RESPONSE:

   Please note that Section 03 64 20 -- Acrylamide Grout Joint Injection, Soil Solidification had a typo in the footer. The sequence listed was 03 64 10 and should have been 03 64 20. In addition, Section 03 64 13 -- Polyurethane Grout, Crack-Joint Injection, had a typo in the numbering and as listed previously as 03 64 15 and should be 03 64 13.

3. Language on sheet 1 indicating joint seal failure due to groundwater or pipe movement should be removed. This is speculative and of no relevance to the work.

   RESPONSE:

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While the opinion has been noted, the second line can be removed from that paragraph.

4. Sequencing includes no information about which end of the pipe they will start at (global directionality). Local directionality of the B-Series work at individual joints seems to be addressed on sheet 4B of the plans. Local directionality of the A-series and C-Series work does not seem to be addressed.

   RESPONSE:

   The contractor can start work from either end or somewhere near the middle, but, does not affect the repair. The starting point of work will be dictated more based upon storm water management and control.
   Regarding the work sequence:
   The project narrative on page 1 describes the Work Sequence, some alterations could occur if desired:
   a.) "A" series work shall be performed first at the pipe joints
   b.) This will immediately be followed by "B" series work at pipe joints.
   c.) Contractor now has option to perform either pipe crack injection or ultra-fine cement injection.
   d.) Any spalls or hole patching should be next.
   e.) The second of the last sequence of work should be the crystalline treatment of fine cracks and surface treatment over grout holes for injection.
   f.) The last treatment shall be the interior joint seals.

5. For the A-Series plans, notes on sheet 8A indicating to move to the next hole "if/when" grout appears at the "adjacent" port do not address the procedure for when grout does not appear at the next port (see comment 9).

   RESPONSE:

   Series "A" grouting with polyurethane is based on establishing a continuous pipe joint plug with the existing asphalt mastic. If asphalt mastic within pipe joint is fully contained and adhered, polyurethane grout may not come out the port hole 16 inches away.

6. For the B-Series plans, item 2 of the sequence on sheet 27B indicates a "specified quantity of grout"; clarify whether this refers to the statement "Pump 3 gallons per 16" O.C. port" on sheet 5B.

   RESPONSE:

   Yes, Series "B" grouting shall be done at 3 gallons per 16" o.c. spacing. That volume was calculated to achieve a continuous plug at concrete pipe joint perimeter. The contractor shall not

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stop pumping series "B" grout if it comes out a port hole 16 inches away. The objective is to get an impermeable mass of solidified soil on each pipe joint exterior side.

If Series "B" grout comes out from any drill hole 16" away that is currently being injected, prior to grouting that hole, re-drill cured grout from hole and inject the specified quantity.

7. For the B-Series plans, the sequencing information on sheet 27B is vague as to which method ("uniform disbursement" or "bottom-up") is to be used and why, and how the decision will be made to use one or the other.

   RESPONSE:

   In series "B" the preference is to use "uniform disbursement" protocol as shown on sheets 4B and 5B. In contrast, sheet 4C, in series "C" drawings show the "bottom up" protocol.

   Normally when clean granular soils exist or when short grout distances are required, "uniform displacement" procedures are used. When the possibility or presence of cohesive soils in the grout zone, better results are achieved with "bottom up" procedures. Bottom up grouting allows for both permeation and fracture grouting to occur.

8. For Spec 03 61 10 (C-Series work), provision 4.5.A.13 calls for SCP test borings at every pipe section, up from 3 borings for the whole run. This seems like overkill. Once the mock-up procedure has been dealt with acceptably, 10-15 borings subject to statistically randomized sampling protocol should be sufficient for the run.

   RESPONSE:

   There is no disagreement with statistically randomized testing. That said, given other previous comments from the Department, CNA requested that every pipe section be tested for structural verification. As such, the current plan included to run the SCP into three drill-hole prior to grouting, and then drill one hole between grouted holes for verification of soil strengthening.

9. For Spec 03 64 13 (A-Series work), there is no Testing and Inspection provision. Provision 4.2 testing for reaction time says nothing about effectiveness of the installation. Clarify whether the information on sheet 5B of the plans regarding use of B-Series work as a check on the A-Series work is supposed to be part of this criteria (ref. comment 5).

   RESPONSE:

   That is correct. During "B" series grouting, if any acrylamide material comes to the pipe joint interior, we know there was a void left by the "A" series grouting. If in the event this starts to occur

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frequently, Brent Anderson and Contractor will make an adjustment in the "A" series grout amount pumped per joint or the port spacing.

10. For Spec 03 64 20 (B-Series work), testing and inspection seems to have moved from 3.8.A.1 to 4.3; this provision now discusses a "visual survey to determine if soil-tightness exists". Surveying for soil-tightness can't be done visually and will require observation of the pipe discharge over an extended time (months). Clarify long-term monitoring procedures.

    RESPONSE:

    Soil particle tightness is related to water tightness. During the ongoing inspections of work over the course of project duration, the degree of joint watertightness will be monitored. As defined in the various specifications:

"Five levels of water accumulation on a concrete element can be physically described as follows:

1. Color change (darker), when high moisture content exists at concrete element surface, (white/crystalline or efflorescence) when area has re-sealed itself via autogenous healing), not visually wet to touch, no ponding occurs;
2. Wet to touch, surface dampness in spots, no sustained water trail present, no ponding occurs;
3. Weeps and seepage, sustained trail of wetness, however, visual surface flow not apparent, ponding does occur;
4. Continuous dripping, visual surface flow or water movement over concrete element, ponding occurs and leaves trail; or
5. Gushing flow, from presence of hydrostatic back pressure, ponding leaves continuous trail of water."

If water leakage in pipe joints is described as item 5 above, I will assume soil particle flow is inevitable. This will require re-grouting. Item 4 above will require closer observation and EOR will determine requirements. Items described in 1, 2, or 3, above will not allow soil particle flow.

11. For Spec 03 64 20 (B-Series work) provision 4.3.B.1, the 10 auger core sample locations need to be statistically randomized to be meaningful.

    RESPONSE:

    We agree and such testing discussions will be part of our Project Documentation.

12. There is still no comprehensive QC/Inspection plan. For complex/unfamiliar work like this, it is useful for clarity to collate those procedures, and the relevant roles/responsibilities into an overall QC plan.

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RESPONSE:

We agree and Brent Anderson is working with the Contractor to develop and submit a plan.

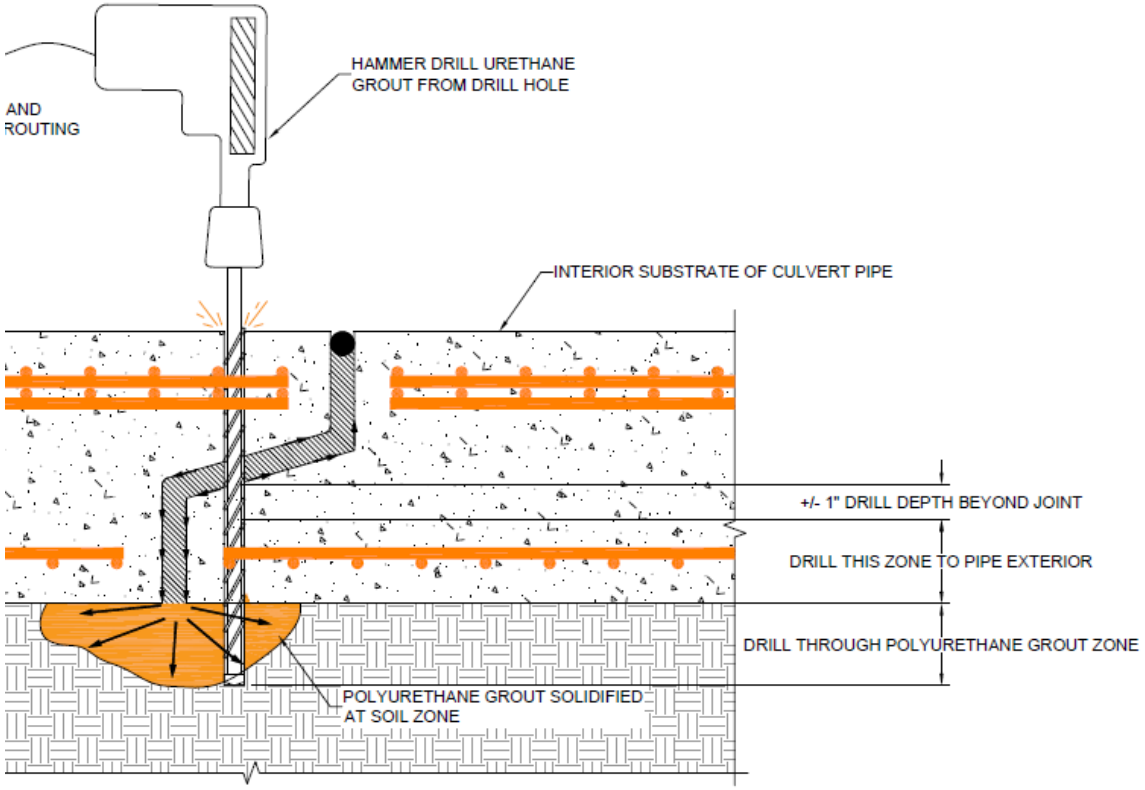
13. BPA plans to drill 5/8" holes at 16" centers around each pipe joint. After the joint is grouted, the grout hole will be drilled through again with a hammer drill to reach through the pipe and past the solidified polyurethane. PBA requires the inner rebar be located with a "GPR or equal" but does not demonstrate that it is possible to miss all rebar, which is sometimes three mats thick. There is no way to avoid rebar on the outside face, and the diagram even shows the drill going through the wire mesh. There is nothing in the plans and specification on how to address this situation, and nothing is included in CNA's Structural Analysis to account for this situation of damaged/disturbed steel reinforcement in all classes of the concrete pipe.

RESPONSE:

We agree that some steel mesh will be cut or compromised in various pipe joints and on occasion in haunch areas. CNA assumed in their calculations that some steel reinforcing mesh would be cut in places.

Tensile steel is located on inside face of tunnel/pipe crown and invert areas. Tensile steel is on outside face at springlines. Project design has drill holes through concrete pipe sections at joints and haunch areas. The pipe joints provide little support from soil lateral pressure because of the fact a gap runs through the section. Cutting steel in this area has little impact on the lateral support. The haunch areas have tensile steel on the inside face where contractor should be able to locate it.

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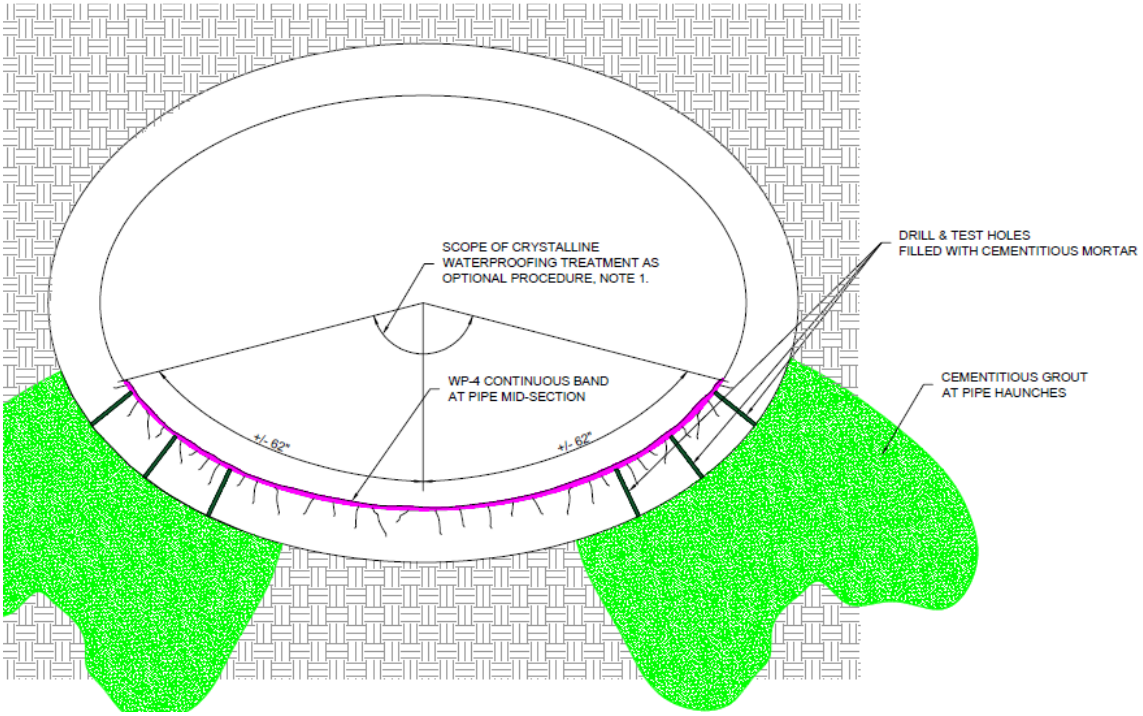


14. Between each joint, 6 ¾" holes will be drilled to inject cementitious grout at pipe haunches. Again, there's no specification to avoid rebar. Why isn't locating rebar required for this procedure. Again, drilling through and damaging or altering the rebar isn't accounted for in CNA's Structural Analysis for any of the pipe classes.

RESPONSE:

The drawings require at all locations scanning inside face of concrete pipe for steel mesh location(s) prior to drilling.

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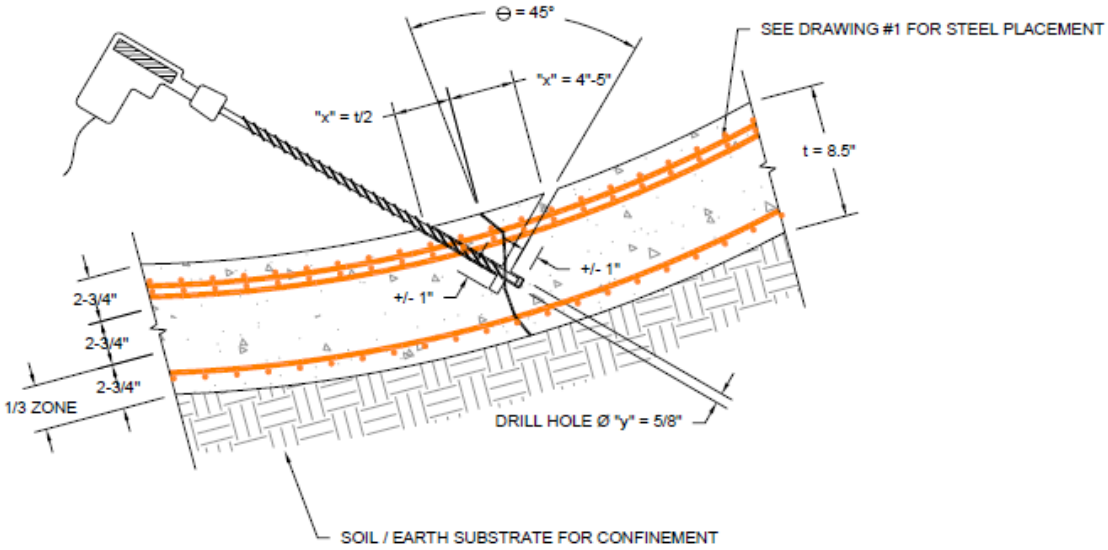


15. Two 5/8" holes will be drilled at each large crack to inject it with grout. These holes will be drilled at an angle and will almost certainly be drilled through the rebar. Again, there is nothing in the plans and specifications on how to address this situation, and nothing is included in CNA's Structural Analysis to account for this situation of damaged/disturbed steel reinforcement in all classes of the concrete pipe.

RESPONSE:

See previous responses regarding scanning prior to drilling.

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16. The cementitious grout will support each pipe section between joints, but it will not reach to the joints, as shown in detail like the one below. CNA did not analyze this condition? What installation type would this be equivalent to?

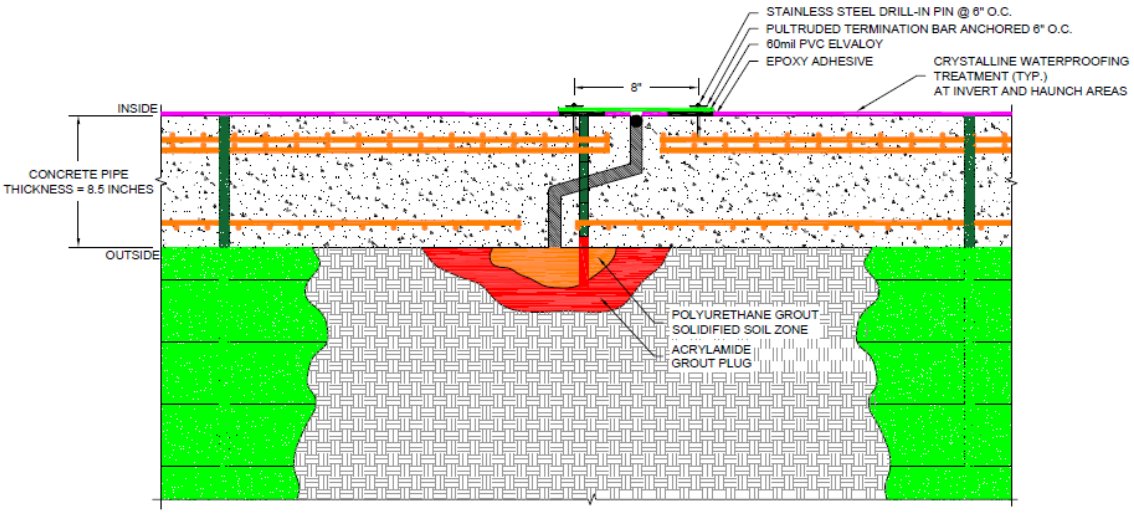
RESPONSE:

In reviewing the plans, CNA did not want large accumulations of cementitious grout at pipe joints. In conjunction with CNA's analysis, BDA moved the cementitious grout hole spacings farther away from the pipe joints. Therefore, Series "A" and "B" work shall be done first. Based on calculated volumes of cementitious grout specified for injection, the goal was to minimize grout penetration around the pipe joint. However, if a large void exists in the haunch that orients to the joint, said void will be filled with cementitious grout.

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CNA Structural Analysis

1. CNA does not have all the information they need about the soil conditions around the pipe. They assume current conditions are a lower Type III installation instead of the required Type II. This needs to be addressed.

   RESPONSE:

   CNA had sufficient information to address the soil around the pipe and the various conditions were considered. Brent Anderson's remediation plan requires the entire pipe length to be grouted. If this is done per plan, CNA is satisfied that the pipe bedding soil conditions will be properly addressed.

2. Well over half of the pipe length did not have useable borings according to CNA analysis. These lengths of unusable borings include many of the pothole locations. Provide a detailed rational for how the submitted analysis took this situation into account.

   RESPONSE:

   CNA did not need extensive borings to provide its analysis. CNA included conservative assumptions for the soil conditions. Brent Anderson's remediation plan requires the entire pipe length to be grouted. If this is done per plan, CNA is satisfied that the pipe bedding soil conditions will be properly addressed.

3. CNA concluded that a Type III installation causes the existing burial depth to exceed design loads for minimum cracking, but since it does not exceed the ultimate capacity, they do not recommend

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replacement. Instead, they recommend a "grouting and testing program to meet a Type II installation".

Table 9: Pipe Class Maximum Burial Depths

Pipe Class	Max Burial Depth	Allowable Max Burial Depth Type II Installation	Allowable Max Burial Depth Type III Installation
III	15 ft	15 ft	11 ft
IV	24 ft	23 ft	17 ft
Special	30 ft	31 ft	23 ft

RESPONSE:

Brent Anderson's remediation plan requires the entire pipe length to be grouted. If this is done per plan, CNA is satisfied that the pipe bedding soil conditions will be properly addressed.

4. They do not do any analysis of the existing pipe conditions beyond assuming a Type III installation. Provide this analysis.

RESPONSE:

CNA analyzed a Type II and Type III condition and determined a Type II condition is required. As such, CNA does not believe it was necessary to perform an analysis with worse conditions.

5. If the soil conditions are actually worse than a Type III installation (especially if there are voids leaving the pipe without support) does the pipe exceed ultimate capacity as it is? If so, would CNA recommend those portions of the pipe be removed?

RESPONSE:

Brent Anderson's remediation plan requires the entire pipe length to be grouted, if this is done all voids under the pipe would be filled and the soil improved to meet a Type II installation.

6. No analysis is done of the pipe post-repair. Do the drill holes significantly change the pipe strength? How will the forces change with the grouting in the haunches? There is no recommendation of what tests need to be done to ensure the repair meets an adequate Type 2 "installation" condition. See comments #13-15 above in the BPA Plan Comments section.

RESPONSE:

CNA took into account Brent Anderson's remediation plan for placing holes in the pipe. The required pipe steel is sized for the pipe bottom and sides. The grout drill holes will be made in the

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haunch areas where less steel is required; and holes will be made with the use of a rebar detector. CNA is satisfied that the structural integrity of the pipes will be maintained post-repair if holes are done per the remediation plan. Grouting of the haunches will increase pipe capacity. Testing of the pipe soil is shown on remediation plan sheet 2C and 4C that is attached.

Above-pipe-springline proposed soil investigation and remediations comments.

1. Concerning the haunch grout remediations**:** Section 03 61 10 (Soil Stabilization) and Section 03 64 20 (Soil Solidification and 'C' Drawings) There appears to be some inconsistencies on the use of 'Soil Stabilization', 'Soil Solidification', and 'Permeation Grouting' language. Section 06 61 10 (1.5 E) defines these terms as interchangeable. But the two referenced Sections have differing titles (i.e. Stabilization vs Solidification) and Permeation grouting also seems to be used interchangeably. This is confusing and needs to be clarified.

   RESPONSE:

   Soil solidification via permeation grouting occurs when a granular soil with less than 20% passing the #200 sieve exists. Soil stabilization occurs via fracture grouting when cohesive or granular soils with more than 20% of the material passes the #200 sieve. Therefore, the reference is such that soil solidification is achieved via permeation grouting and soil stabilization is achieved via fracture grouting. However, it can be said that once the soil is grouted with either permeation or fracture grouting it is more stable and commonly referred to as soil stabilization.

2. Section 03 64 10 (4.3 Testing and Inspection) discusses 'permeation grouting' verification testing by obtaining 'auger core samples'. Assuming these are auger samples (disturbed) and not true core samples (i.e. undisturbed), it will be very difficult to determine what 'inconsistent samples' are that require re-work. Besides the difficulty, there is no guidance on how 'consistency' is measured/determined or what thresholds are acceptable. There is language discussing grout filling of 85% of pore space, but is there a way to field/laboratory measure this? Provide an acceptable testing method to meet this specification.

   RESPONSE:

   Geotechnical engineering does not have test methods for some conditions which may occur in practice. The auger core samples will be analyzed by BDA which is the Engineer of Record. Evaluation requires engineering judgement by the EOR.

3. 03 61 10 (4.3 A Testing and Inspection) requires borings "to confirm the extent and effectiveness of the grouting program". It appears these are to be undisturbed samples (Shelby Tube), since unconfined compression tests may be performed. Shelby tubes will not allow examination in the field, as specified. Besides this issue, there is no guidance on what the acceptance criteria is for these samples. Provide an acceptable testing method and process to meet this specification.

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RESPONSE:

The answer is similar to above, auger core samples will be analyzed by BDA. Evaluation requires engineering judgment by the EOR.

4. Section 'C' plan sheets detail verifying acceptable grouting through the use of static cone penetrometer in holes through the pipe invert and haunches, before and after grouting operations. Acceptance criteria is to "achieve a 25% increase is soil strength". There also needs to be a minimum strength threshold set. i.e. A very, very loose zone may achieve a 25% increase, but this may still not be adequate to provide proper pipe support.

   RESPONSE:

   Cementitious grouting will increase soil resistance strengths in very loose zones by a factor of several times, beyond the 25% increase. Our goal will be to have soil bearing resistances OF 3,000 psf. If we encounter loose granular soil with voids, its capacity will be very low, however, after grouting it should exceed 3,000 psf.

   Conversely, what if the initial cone test provides a very high soil strength value, and the contractor cannot achieve the 25% increase?

   RESPONSE:

   Granular soil which is already high bearing capacity in theory and practice will not require grouting. The grout will just fill the pore space and make it stronger and more impermeable. Again, engineering judgment would tell you we do not need to accommodate the 25% increase in soil strength as specified in these cases. Further it will be difficult to measure in the field.

5. For grouting acceptance will all three methods be used for all acceptance grouting verification. What if all three do not agree?

   RESPONSE:

   This is where the EOR will determine acceptance or not.

6. Borings that must be advanced very close to the outside of the pipe (immediate haunch area) may be difficult to locate in the proper location at depth, or cause damage to the pipe. Provide an acceptable testing method and process to meet this specification.

   RESPONSE:

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Brent Anderson would agree that classic soil testing from the surface will not tell us much about how effective the grouting procedures have been for the reason stated. Brent Anderson is not suggesting we try such testing, as it may not bear useful results.

Comments on Barr's Geophysical Investigation and Mitigation of Backfill dated January 22, 2020.

We also submitted the Department's comments on Barr Engineering's proposal to Barr for review. Attached is the response from Barr Engineering to the comments. As you may recall, we were mobilizing to begin MASW testing in February, however, given the uncertainty with the Department's approval of the repair plan and/or Barr's proposal, we postponed proceeding with same.

Respectfully,

Dan Weinkauf

Attachment as indicated.	(2/28/20 Response from Barr)
Attachment as indicated	(Revised 2C)
Attachment as indicated	(Revised 4C)

cc: Carrie Cox (Carrie.Cox@dot.wi.gov)
Dan Weinkauf (Dan@integrityge.com)
Kevin Long (Kevin.long@quarles.com)
Bradley Fisher (bfisher@fisherbren.com)
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March 5, 2020

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Website: www.fisherbren.com

Re: Raymond Road Elliptical Pipe Project
Subj: Quality Control and Quality Assurance Program
Attn: Dan Weinkauf, President

The Quality Control and Quality Assurance aspect is an instrumental part of the restoration process for Raymond Road elliptical concrete pipe project. Outlined below is an estimated budget for this work. Preparatory work on the QA/QC program is currently in place and will be billed at the hourly rate in place. Project submittal review will also be billed at the prescribed hourly rate already established.

This budget will be based on getting set up at the site 4 days prior to contractor starting the mock-ups. This first week will include training on material and equipment prior to mock-ups. During mock-ups EOR will be on site full time (part of 1st shift and part of 2nd shift for the first week.

When mock-ups are approved, and project starts; the plan at this time is as follows:

1.) Week 1:
    a. Monday: 5-hrs travel; 5-hrs with 1st crew and 5-hrs with 2nd crew,

* Hazardous Gas Control
* Air & Vapor Barrier
* Soil Solidification
* Expansion Joints
* Chemical Grouting
* Forensic Engineering
* Green Roofing
* Single Ply Roofing

b. Tuesday: 10-hrs on site, 5-hrs with 1st crew and 5-hrs with 2nd crew,
c. Wednesday: 10-hrs on site, 5-hrs with 1st crew and 5-hrs with 2nd crew,
d. Thursday: 10-hrs on site, 5-hrs with 1st crew and 5-hrs with 2nd crew,
e. Friday: 10-hrs on site, 5-hrs with 1st crew and 5-hrs with 2nd crew,
f. Saturday: 5-hrs travel.

2.) Weeks 2 – 12:
a. Monday morning: drive to jobsite, spend 5 hours on site with 1st crew,
b. Tuesday: 10-hrs on site, 5-hrs with 1st crew and 5-hrs with 2nd crew,
c. Wednesday: 10-hrs on site, 5-hrs with 1st crew and 5-hrs with 2nd crew,
d. Thursday morning: 5-hrs travel,
e. Friday: 3-hrs, QA/QC data review from previous day's work.

3.) Project Closeout:
a. Project closeout review will also be billed at the prescribed hourly rate already established.

Based on this schedule I estimate the QA/QC work will cost $125,000.00 to $175,000.00. Please contact me to define this more in more detail if required. This QA/QC work will be independent of any personnel the Department of Transportation may require on site.

Sincerely,

Brent Anderson

Brent Anderson, PE
Registration # 23802-6

CONSULTING ENGINEERS

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Minneapolis MN 55414
(612) 379-8805

January 16, 2020

Dan Weinkauf
Integrity Grading & Excavation, Inc.
605 Grossman Dr.
Schofield, WI 54476

RE: BDA Repair Plans for Raymond Road Tunnel; WisDOT Project 5992-09-83

Dear Mr. Weinkauf:

CNA's Pipe Inspection Report dated 11/21/19, recommended 4 items be repaired to bring the pipe up to a good condition: Repair: cracks, joints, lift holes and spalled concrete. CNA's Pipe Structural Analysis Report dated 1/16/2020, recommends a 5th item: the pipe haunch bedding be grouted and tested for the pipe to be rated structurally acceptable.

I have reviewed the repair plans for Raymond Road Tunnel, WisDOT project 5992-09-83 prepared by BDA Associates, LLC, dated 1/9/2020. I have the following comments:

1. Plan sheet 1 and the D, E, F series sheets address pipe crack sealing repair that matches the CNA report crack sizes to repair. If repairs are done correctly and inspected per the BDA plans and specifications it will satisfy the crack repair requirements.
2. Plan Sheet 2 & 3 address repairing lifting and tie holes that matches the CNA report for repairs. If repairs are done correctly and inspected per the BDA plans and specifications it will satisfy the hole repair requirements.
3. Plan sheet 2 address repairing spalled concrete that matches the CNA report for repairs. If repairs are done correctly and inspected per the BDA plans and specifications it will satisfy the spalled concrete repair requirements.
4. The A, B, and G series plan sheets address repairing of all joints that matches the CNA report for repairing all joints. If repairs are done correctly and inspected per the BDA plans and specifications it will satisfy the repairing of all joint repair requirements.
5. The C series plan sheets address grouting the pipe bedding haunch soil and testing that matches the CNA report for grout location. If repairs are done correctly and inspected per

the BDA plans and specifications it will satisfy the verification of the pipe bedding installation. A mock-up test section will have to be done per sheet 4C to verify grouting and testing methods.

If these 5 items are performed, the pipe can be rated in good condition and structurally acceptable.

The pipe should be periodically inspected in the future to see if pipe conditions have changed.

CNA observations, opinions, recommendations and analysis are based on the limited information available to us at the time of this report. We recognize that additional data, field testing, design background and other considerations may exist but have not yet been incorporated into our considerations. We will review additional data, should such information be made available to us, and it appropriate revise our analysis, conclusions and recommendations if they are affected by the additional information.

Sincerely,



Brent K. Nelson, P.E.

WisDOT Project #5992-09-83
Raymond Road Storm Tunnel
Pipe Structural Analysis Report



Prepared by:
CNA Consulting Engineers
2800 University Avenue SE
Minneapolis, MN 55414

January 2020

Certification

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly licensed Engineer under the laws of the State of Wisconsin.

Name: Brent K. Nelson, P.E.

Signature: Brent K Nelson

Date: 01/16/2020 Lic. No.: 28234



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Attachment A: Horizontal Elliptical Pipe Shop Drawings
Attachment B: Eriksson Pipe Output for Class III
Attachment C: Eriksson Pipe Output for Class IV
Attachment D: Eriksson Pipe Output for Class Special
Attachment E: PipePac Output
Attachment F: AASHTO Indirect Design Calculations
Attachment G: Raymond Rd Sewer – Boring and Pipe Classes Drawings
Attachment H: Pipe Installation Photos

1. Introduction

1.1. Introduction

The Wisconsin Department of Transportation (WisDOT) developed a project to improve a section of CTH M in Dane County and sections of the intersecting streets in Madison and Verona, WI. MSA Professional Services performed the engineering design. The project involved installation of a 68-inch by 106-inch horizontal elliptical pipe for approximately 3,300 feet underneath Raymond Road. Integrity Grading and Excavation (IGE) was the General Contractor for the project and subcontracted the pipe installation to Speedway Sand and Gravel, Inc. County Materials provided the precast pipe.

After the installation of the pipe and the paving of Raymond Road, surface depressions were found above the pipe at multiple locations. CNA did an inspection of the pipe in October 2019 and prepared an inspection report in November 2019.

This report summarizes the structural analysis of the elliptical pipe that was installed.

1.2. Background

This report documents the structural analysis of the tunnel pipe. The tunnel pipe, designed in 2017, consists of a 68-inch by 106-inch horizontal elliptical pipe. The tunnel contains 3 pipe classes over the length:

500+50 to 504+00 – Class IV
504+00 to 509+00 – Class Special
509+00 to 519+15 – Class IV
519+15 to 533+54 – Class III

The elliptical concrete pipe and associated manholes were installed in late 2017 and early 2018. The pipe was installed using an open cut trench excavation by Speedway. The pipe was provided by County Materials following submittals that provided the pipe requirements including the use of a bituminous mastic in the joints.

CNA analyzed the pipe following ASTM C507, per WisDOT's request on the phone call on October 24, 2019.

This report categorizes and quantifies the structural analysis of the tunnel pipe.

1.3. Project Scope

CNA's scope of work for this project is to provide professional engineering services to inspect and evaluate the pipe condition, provide a structural analysis of the tunnel pipe and review remediation options for the tunnel pipe. The scope of work contains multiple phases:

Scope of Work

Phase 1-3 and 5 are not included in this report. Refer to CNA's Raymond Road Storm Tunnel Pipe Inspection Report dated November 2019 for details on Phase 1-3.

Phase 1: Information Gathering

- Review tunnel records and previous reports.

- Conduct a condition survey of the tunnel pipe.
- Identity features and tabulate the inspection finding.
- Document conditions.

Phase 2: Evaluation

- Evaluate the tunnel pipe condition from the visual inspection.

Phase 3: Condition Report

- Tabulation of the conditions.
- Evaluate the tunnel pipe condition from visual inspection.

Phase 4: Structural Analysis Report

- Structural analysis of the tunnel pipe.

Phase 5: Rehabilitation Review Report

- Review the pipe maintenance and pipe rehabilitation options provided by BDA Associates, LLC, Minneapolis, MN.

2. Structural Analysis Procedure

2.1. Introduction

The structural analysis of the horizontal elliptical pipe used three different analysis methods to review the structural condition. The methods used were the PipePac Three Edge Bearing analysis, the Pipecar Three Edge Bearing analysis and AASHTO's Indirect Design Method. Each method will be discussed below.

The analysis methods required the knowledge of material and geological properties and construction procedures. Material properties include the pipe dimensions, reinforcement areas, reinforcement strengths and concrete strengths.

Geological properties of both the native and backfill soils are required. Properties include the unit weights, friction angle and coefficient of friction.

The procedures that the contractor used for the placement of the pipe effect the pipes structural capacity. The excavated width of the trench is required and effects other properties. The material used for the bedding, backfill, and compaction is required and effects other design values used for the analysis.

2.2. Eriksson Pipe Three Edge Bearing Analysis

Eriksson Pipe software contains a Three Edge Bearing (3EB) analysis program. The 3EB program uses the pipe geometry and pipe material properties to calculate either the D-Load capacities when given the pipe inside reinforcement area or the required reinforcement area when given the specified D-Loads.

The pipe geometry required is the pipe shape, span, wall thickness and the reinforcement cover. Material properties included in the analysis include the reinforcement yield and ultimate stresses,

reinforcement type and spacing and the concrete strength. The design failure criteria can be changed between yield and ultimate.

For the structural analysis of the elliptical pipe, the reinforcement area that was provided in the shop drawings for the three classes used were inputted. When specifying the reinforcement area the D-Load capacity analysis is based only on the inside reinforcement area. The ultimate D-Load value will be higher than the capacity given in Erikkson Pipe if stirrups are included in the reinforcement. For the Class IV pipe the 3EB program will be run inputting the required D-Load values to check the stirrup requirements. The relationship between the $D_{0.01}$ Load and D_{ult} Load is 1.5 for $D_{0.01}$ less than 2,000 lb/ft/ft, 1.25 for $D_{0.01}$ more than 3,000 lb/ft/ft and is interpolated between 1.5 and 1.25 for $D_{0.01}$ between 2,000 lb/ft/ft and 3,000 lb/ft/ft. Below is Table 1 with the geometry, material properties and design coefficients. The reinforcement areas for each of the pipes are discussed and provided in Section 4. See Attachment A for the provided shop drawings.

Table 1: Eriksson Pipe Inputs

Pipe Geometry and Material Properties				
Inside Reinforcement Cover	1 in		Reinforcement Yield Stress	65 ksi
Outside Reinforcement Cover	1 in		Reinforcement Ultimate Stress	75 ksi
Circum. Reinforcement Spacing	2 in		Design Criteria	Ultimate
Stirrup Strength	60 ksi		Concrete Strength	6 ksi
Design Coefficients				
Flexural Strength Reduction	0.95		0.01” Crack Strength Reduction	0.95
Diag. Tension Strength Reduction	0.9		Rad. Tension Strength Reduction	0.9
A_{so}/A_{si}	0.6		C_x (for inside reinf.)	1

2.3. PipePac Three Edge Bearing Analysis

PipePac software, provided by the American Concrete Pipe Association (ACPA), contains a Three Edge Bearing (3EB) Analysis program. The 3EB analyzes concrete in accordance to the methods provided in the ACPA Concrete Pipe Manual. The program analyzes underground pipe for the standard installation conditions and loads derived from the indirect design method. All standard live load types can be specified.

The program starts with the inputting of the units and standard of design. Then the pipe shape, type, and basic dimensions are inputted.

With the pipe information inputted, the loading and installation information is inputted. The soil type is selected. The other required soil properties will be used after the selection of the installation type. The minimum and maximum fill heights over the pipe can be set and the incremental height between the minimum and maximum where the loading will be calculated. A live load type can be selected and be modified from the standard values. The final selection is the bedding types that will be analyzed.

With the inputs in place, the analysis is run and the required pipe class for the given fill heights are calculated for each of the bedding types that were selected. The output file provides the calculated loads, arching and bedding factors, and the required D-Load for 0.01-inch crack.

Table 2 contains the inputs for the loading and installation condition used for the calculations. No Live Loads were applied because the minimum pipe depth is greater than 10 feet below the road.

Table 2: PipePac Inputs

Minimum Fill Depth	10 ft	Maximum Fill Depth	35 ft
Soil Density	120 pcf	Soil Lateral Pressure Ratio (K_a)	0.33
Soil Lateral Pressure/Friction Term (Kμ)	0.165	Soil Lateral Fraction (m)	0.70
Settlement Ratio	0.70		
Installation Type	Positive Projecting Embankment	Projection Ratio	0.30, 0.50, 0.70, 0.90

2.4. AASHTO Indirect Design Method

Reinforced concrete pipe is controlled by Article 12.10 in the AASHTO LFRD Bridge Design Specifications, 8th Edition. The pipe can be designed using one of two methods: direct design at strength limit state or indirect design at service limit state. The indirect design method is the most commonly used method for design and was used for this analysis.

The indirect design method calculates a design load determined for the pipe as installed. The design load is then compared to the D-Load at a 0.01-inch wide crack as specified in AASHTO M207. The design load is calculated by dividing the unfactored loads applied to the pipe by a bedding factor. The earth and fluid loads applied to the pipe are divided by an earth load bedding factor. The live load applied is divided by a live load bedding factor.

The earth load is calculated as the column of soil over the outside horizontal dimension of the pipe multiplied by a soil-structure interaction factor. The soil-structure interaction factor accounts for any transfer of the soil over the regions on the side of the pipe because the pipe is more rigid than the soil on the sides. AASHTO specifies this interaction factor as the vertical arching factor for the installation type that is designed for. The pipe fluid weight is calculated as the area of the pipe multiplied by the unit weight of water. The live load is specified in AASHTO Article 3.6. The article states that live load only needs to be considered when the structure is located shallower than 8ft or exceeds the span length. For this design the depth of the pipe is deeper than the limits.

The AASHTO calculations use similar inputs that were used for the PipePac calculations but for Type 2 installations the projection ratio is limited to 0.9 and 0.7, while Type 3 installations use either a 0.5 or 0.3 projection ratio. The calculations also were only performed for the maximum burial depth for each class of pipe installed, see Table 3.

Table 3: Maximum Burial Depths

Pipe Class	Station	Burial Depth [ft]
III	520+71	15.1
IV	509+00	24.3
Special	506+14	30.2

3. Structural Analysis Results

3.1. Introduction

This section provides the results of the calculations performed using the three different methods discussed above. The Eriksson Pipe analysis lists each of the pipe classes that were analyzed and provides the Design Loads. The PipePac analysis provides the summary of the results in a graphical table for the bedding and project ratios that were evaluated. The AASHTO Indirect Design method provides the maximum fill heights that the pipe classes can withstand.

3.2. Eriksson Pipe Three Edge Bearing Analysis

3.2.1. Class III Pipe Results

The reinforcement section design for the Class III Elliptical Pipe has three steel reinforcement cages each having a 0.45 sq. in./ft steel area (Attachment A). There is one full wrap cage on the inside and outside and a middle elliptical cage that merges with the inside at the crown and invert and the outside cage at the springlines. The resulting steel area on the inside at the crown and invert and on the outside at the springlines is 0.90 sq. in/ft.

The concrete and wire information provided by County Materials to SGH shows that the minimum tested concrete compressive strength of 7,000 psi, minimum yield strength of 81.2 ksi and tensile strength of 91.6 ksi.

We calculated the D-Load capacity of the pipe using Eriksson Pipe and the concrete and reinforcement strengths given above in Section 2.2. Type 2 reinforcement (welded smooth wire fabric) was selected. The calculated D-Load Capacity at 0.01 in crack ($D_{0.01}$) = 1,526 lb/ft/ft and an ultimate D-Load Capacity (D_{ult}) = 2,130 lb/ft/ft. See the Eriksson Pipe output in Attachment B. These calculated D-Load capacities exceed the minimum required values specified in ASTM C507 for the Class III horizontal elliptical pipe.

3.2.2. Class IV Pipe Results

The reinforcement section design for the Class IV pipe was designed by Engineered Wire Products for County Materials. The section design calls out the reinforcement by wire size and spacing of the wires. The inside cage is made of a full wrap of W10.0 (0.10 sq. in.) wire at 2-inch spacing that provides 0.6 sq. in/ft steel area (0.10 sq. in. * 6 wires per ft (12in/2in spacing)). The inside cage is then supplemented with another mat of W10.0 at 2-inch spacing at the crown and invert, providing a total inside reinforcement of 1.2 sq. in/ft. The outside cage reinforcement is a single full mat of W7.5 (0.075 sq. in.) wire at 2-inch spacing (area of steel = 0.45 sq. in./ft) supplemented with another 2 mats of W7.5 at 2-inch spacing (area of steel 0.90 sq. in./ft) at the springlines. The outside reinforcement at the springlines has a total steel area of 1.35 sq. in./ft. The reinforcement design also shows stirrup reinforcing of 0.087 sq.in/ft/line and 17 lines spaced at 4-inches centered at the crown and invert.

The concrete and wire information provided by County Materials to SGH shows that the minimum tested concrete compressive strength of 5,940 psi for the Class IV with an

average of 7,275 psi. The wire certificates show a minimum yield strength of 79.7 ksi and tensile strength of 87.2 ksi.

We calculated the D-Load capacity of the pipe using Eriksson Pipe and the concrete and reinforcement strengths given above in Section 2.2. Type 3 reinforcement (welded deformed wire fabric, deformed bars or any reinforcement with stirrups) was selected. The calculated D-Load Capacity at 0.01 in crack ($D_{0.01}$) = 2,064 lb/ft/ft and an ultimate D-Load Capacity (D_{ult}) = 2,424 lb/ft/ft. See the Eriksson Pipe output using the specified reinforcement area in Attachment C. The calculated $D_{0.01}$ capacity exceeds the ASTM C507 minimum required value for Class IV elliptical pipe. We then calculated the required reinforcement areas for the specified D-Loads of $D_{0.01}$=2000 lb/ft/ft and D_{ult}=3000 lb/ft/ft (C507 minimum values). The governing design gives an inner reinforcement area of 1.16 sq. in./ft and stirrup area of 0.098 sq. in./ft/line and 16 lines at 4.5 inches. See the Eriksson Pipe output using the specified D-Load values in Attachment C. The provided inner reinforcement area is greater than required and the stirrup design provides the equivalent steel area.

3.2.3. Class Special Pipe Results

The reinforcement section design for the Class Special pipe was designed by Engineered Wire Products for County Materials based on the design provided by Cooper Engineering. The inside cage is made of a full wrap of W9.5 (0.095 sq. in.) wire at 2-inch spacing that provides 0.57 sq. in/ft steel area. The inside cage is then supplemented with another 2 mats of W9.5 at 2-inch spacing at the crown and invert, providing a total inside reinforcement of 1.71 sq. in/ft. The outside cage reinforcement is a single full mat of W10.5 (0.105 sq. in.) wire at 2-inch spacing (area of steel = 0.63 sq. in./ft) supplemented with another 2 mats of W10.5 at 2-inch spacing (area of steel 1.26 sq. in./ft) at the springlines. The outside reinforcement at the springlines has a total steel area of 1.89 sq. in./ft. The reinforcement design also shows stirrup reinforcing of 0.140 sq.in/ft/line and 20 lines spaced at 4.5-inches centered at the crown and invert.

The concrete and wire information provided by County Materials to SGH shows that the minimum tested concrete compressive strength of 7,690 psi for the Class IV with an average of 8,438 psi. The inside reinforcing wire certificates show a minimum yield strength of 83.7 ksi and tensile strength of 87.6 ksi.

We calculated the D-Load capacity of the pipe using Eriksson Pipe and the concrete and reinforcement strengths given above in Section 2.2. Type 3 reinforcement (welded deformed wire fabric, deformed bars or any reinforcement with stirrups) was selected. The calculated D-Load Capacity at 0.01 in crack ($D_{0.01}$) = 2,693 lb/ft/ft and an ultimate D-Load Capacity (D_{ult}) = 2,925 lb/ft/ft. With a $D_{0.01}$ between 2,000 lb/ft/ft and 3,000 lb/ft/ft, the factor of safety to get the D_{ult} is interpolated and calculates to 1.32. Thus the D_{ult} = 1.32*2,693lb/ft/ft = 3,554 lb/ft/ft. See the Eriksson Pipe output using the specified reinforcement area in Attachment D. ASTM C507 does not have specified D-Load values for special design pipes. The calculated D-Load values were be compared to the other analysis methods used, to meet the design requirements.

3.3. PipePac Three Edge Bearing Analysis

The PipePac Analysis outputted tables for the each of the installation bedding types and project ratios for the positive projecting embankment installation type with the tables providing the required D-Load for a 0.01-inch crack for each pipe depth between 10 feet and 35 feet deep. The calculations use a variable arching factor for the calculation of the total load and variable bedding factors for the calculation of the D-Load. Table 4 shows the $D_{0.01}$ Load for the pipe depths that are allowed for each pipe class for a Type 2 bedding and the analyzed project ratios. Table 5 shows the same information for Type 3 bedding. Class III and Class IV are based on the $D_{0.01}$ Load from ASTM C507. The Class Special pipe uses the $D_{0.01}$ Load of 2,693 lb/ft/ft to find the maximum burial depth. See Attachment E for the outputs from PipePac.

Table 4: PipePac - Type 2 Installation Results

	Projection Ratio			
Pipe Depth	0.9	0.7	0.5	0.3
10	766	815	861	891
11	850	902	950	982
12	937	991	1042	1077
13	1026	1083	1137	1163
14	1119	1179	1236	1245
15	1215	1278	1337	1327
16	1315	1380	1429	1409
17	1418	1486	1514	1490
18	1525	1588	1599	1572
19	1635	1675	1684	1653
20	1740	1760	1769	1735
21	1827	1846	1853	1816
22	1913	1933	1937	1898
23	1999	2018	2022	1979
24	2087	2104	2106	2061
25	2173	2189	2190	2142
26	2258	2274	2275	2224
27	2344	2359	2359	2305
28	2430	2445	2443	2386
29	2516	2530	2527	2468
30	2602	2615	2611	2549
31	2687	2700	2696	2631
32	2773	2786	2780	2712
33	2859	2871	2864	2794
34	2944	2956	2948	2875
35	3030	3041	3032	2956

Class III
Class IV
Class Special

Table 5: PipePac - Type 3 Installation Results

	Projection Ratio			
Pipe Depth	0.9	0.7	0.5	0.3
10	957	1006	1052	1083
11	1060	1112	1161	1193
12	1167	1222	1273	1307
13	1278	1335	1388	1412
14	1392	1452	1508	1511
15	1510	1572	1632	1611
16	1633	1698	1744	1710
17	1759	1827	1848	1809
18	1890	1952	1951	1908
19	2026	2058	2055	2007
20	2154	2163	2158	2106
21	2261	2268	2261	2205
22	2368	2375	2364	2304
23	2474	2479	2466	2403
24	2582	2584	2569	2502
25	2688	2689	2672	2601
26	2794	2793	2774	2699
27	2900	2898	2877	2798
28	3005	3002	2980	2897
29	3111	3107	3082	2996
30	3217	3211	3185	3095
31	3323	3316	3288	3193
32	3428	3420	3390	3292
33	3534	3525	3493	3391
34	3640	3629	3595	3490
35	3745	3734	3698	3589

3.4. AASHTO Indirect Design Method

AASHTO calculations output the required design load for each of the pipe classes installed at their deepest burial depth for both Type 2 and Type 3 installations and the corresponding project ratios. Tables 6 and 7 summarize the design load calculations and compares the results to the required D-Load listed in ASTM C507. See Attachment F for the AASHTO Indirect Design calculations.

Table 6: Summary of Design Load Calculations for Installation Type 2

Pipe Class	Station	Burial Depth	Bedding Factor		Design D-Load (lb/ft/ft)		C507 $D_{0.01}$ Crack Load (lb/ft/ft)	C507 D_{ult} Load (lb/ft/ft)
			p=0.9	p=0.7	p=0.9	p=0.7		
Class III	520+71	15.1	2.41	2.30	1328	1390	1350	2000
Class IV	509+00	24.3	2.39	2.29	2099	2187	2000	3000
Special	506+14	30.2	2.38	2.29	2587	2693	2693*	3554*

* Value for $D_{0.01}$ taken from the Eriksson Pipe Three Edge Bearing Calculation

Table 7: Summary of Design Load Calculations for Installation Type 3

Pipe Class	Station	Burial Depth	Bedding Factor		Design D-Load (lb/ft/ft)		C507 $D_{0.01}$ Crack Load (lb/ft/ft)	C507 D_{ult} Load (lb/ft/ft)
			p=0.5	p=0.3	p=0.5	p=0.3		
Class III	520+71	15.1	1.81	1.77	1768	1809	1350	2000
Class IV	509+00	24.3	1.81	1.77	2773	2833	2000	3000
Special	506+14	30.2	1.81	1.77	3411	3483	2693*	3554*

* Value for $D_{0.01}$ taken from the Eriksson Pipe Three Edge Bearing Calculation

We back-calculated the maximum allowable height of soil that is allowed according to the AASHTO procedures, as shown in Table 8.

Table 8: Maximum Allowable Fill Heights

Pipe Class	C507 $D_{0.01}$ Crack Load (lb/ft/ft)	Installation Type	Projection Ratio	Maximum Height of Fill above Pipe
Class III	1,350	2	0.9	15.3
			0.7	14.5
		3	0.5	11.1
			0.3	10.8
Class IV	2,000	2	0.9	23.1
			0.7	22.1
		3	0.5	17.1
			0.3	16.7
Class Special	2,693*	2	0.9	31.4
			0.7	30.2
		3	0.5	23.5
			0.3	23.0

* Value for $D_{0.01}$ taken from the Eriksson Pipe Three Edge Bearing Calculation

4. Discussion

4.1. Introduction

This section discusses the findings of the three different analysis methods regarding each of the pipe classes that were installed.

4.2. Discussion

4.2.1. Class III Pipe

For a Class III pipe, ASTM C507 states that the $D_{0.01}$ Load = 1,350 lb/ft/ft and the D_{ult} Load =2,000 lb/ft/ft. Eriksson Pipe calculated a $D_{0.01}$ Load = 1,526 lb/ft/ft and D_{ult} Load = 2,130 lb/ft/ft, thus the design pipe meets the requirements of C507 for a Class III pipe.

PipePac calculated a maximum burial depth of between 12 feet and 16 feet for a standard C507 Class III pipe. This range is dependent on the installation assumptions.

The AASHTO Indirect Design calculations show that the maximum allowable fill height is between 10.8 feet and 15.3 feet depending on the assumed installation condition. If the pipe was installed to a Type 2 Installation with a projection ratio of 0.9, the pipe would meet the requirements of the AASHTO LRFD Bridge Design Specifications.

Based on the calculations the Class III pipe and the maximum burial depth shown on the plans the pipe in a Type 3 installation would be expected to have some cracking at the higher burial depths, but the ultimate D-Load requiring pipe replacement would not be reached.

4.2.2. Class IV Pipe

For a Class IV pipe, ASTM C507 states that the $D_{0.01}$ Load = 2000 lb/ft/ft and the D_{ult} Load =3,000 lb/ft/ft. Eriksson Pipe calculated a $D_{0.01}$ Load = 2064 lb/ft/ft, which meets the requirement for a C507 Class IV pipe. The calculation of the minimum reinforcement for a Class IV pipe, shows that the pipe will also meet the D_{ult} Load.

PipePac calculated a maximum burial depth of between 18 feet and 23 feet for a standard C507 Class IV pipe. This range is dependent on the installation assumptions.

The AASHTO Indirect Design calculations show that the maximum allowable fill height is between 16.7 feet and 23.1 feet depending on the assumed installation condition. If the pipe was installed to a Type 2 Installation with a projection ratio of 0.9, the pipe would meet the requirements of the AASHTO LRFD Bridge Design Specifications, the maximum burial depth is within 1 ft of allowable.

Based on the calculations the Class IV pipe and the maximum burial depth shown on the plans the pipe in a Type 3 installation expected to have some cracking at the higher burial depths, but the ultimate D-Load requiring pipe replacement would not be reached.

4.2.3. Class Special Pipe

Eriksson Pipe calculated a $D_{0.01}$ Load of 2,693 lb/ft/ft for the Class Special pipe.

PipePac calculates a maximum burial depth of between 25 feet and 31 feet for the Class Special pipe, using the $D_{0.01}$ Load calculated by Eriksson Pipe, depending on the assumptions used for the pipe installation.

The AASHTO Indirect Design calculations show that the maximum allowable fill height is between 23.0 feet and 31.4 feet depending on the assumed installation condition and a $D_{0.01}$ Load calculated from Eriksson Pipe. If the pipe is installed to a Type 2 Installation, the requirements of the AASHTO LFRD Bridge Design Specifications would be met.

Based on the calculations the Class Special pipe and the maximum burial depth shown on the plans the pipe in a Type 3 installation expected to have some cracking at the higher burial depths, but the ultimate D-Load requiring pipe replacement would not be reached.

4.3. Required Information needed to verify Structural Analysis of Pipe

Speedway Sand and Gravel did not produce any: photographs of the bedding or backfill; inspection reports describing bedding and backfill or compaction information. However, IGE informed CNA that 1 ¼ inch dense graded base rock was to be placed below the pipe and then backfilled with Grade 2 granular backfill.

The attached photo shows a trench box being used and above that the soil is laid back. For analysis, we used the positive projecting embankment shape, a conservative and most likely shape used for the analysis.

From the description given by IGE, this projection ratio is most likely a 0.9 ratio, which was used in the analysis with other ratios.

Borings taken after pipe backfilling are summarized on the attached drawings. A photo (attached) of trench box used for pipe placement shows there is approximately 3 feet between outside of pipe and trench box. Therefore, the borings had to be within 3 feet of the pipe to encounter backfill material. Attached drawings show the closer borings to the pipe, B17, B16, B15, B10, B9, B8, B7 and B5, show the backfill at pipe elevation to be Poorly Graded Sand with Silt (SP-SM). The other further away borings show silts, clays and silty sand at the pipe elevation.

Subsurface subsidence was observed, slightly open joints in the pipe were observed, and sand was observed in the pipe. Voids or loose soil under the pipe is a potential issue being addressed by grouting the pipe bedding soil in the plans prepared by BDA.

A pipe structural analysis requires the pipe bedding material and backfill material be inputted at the pipe haunches; these are variable. Looking at the soil borings and blow counts, we can surmise the bedding and backfill could be a Type 2 if it was compacted and did not flow into the pipe through the open joints. Since the compaction and soil can be variable, using a Category II soil, slightly compacted, would yield a Type 3 installation condition. A Type 2 installation condition is better for pipe strength.

Using assumed soil, compaction, excavation shape and projection ratios the following Table 9 was produced to create the maximum bury depths from the results of the three analysis. These depths are conservative because the concrete and reinforcement strengths tested are higher than used in the analysis.

Table 9: Pipe Class Maximum Burial Depths

Pipe Class	Max Burial Depth	Allowable Max Burial Depth Type II Installation	Allowable Max Burial Depth Type III Installation
III	15 ft	15 ft	11 ft
IV	24 ft	23 ft	17 ft
Special	30 ft	31 ft	23 ft

A Type 2 installation shows the pipe should not be overstressed.

If a Type 2 pipe installation condition can be verified by field tests that the bedding meets Type 2 installation conditions the pipe can be structurally rated acceptable.

A Type 3 installation shows the pipe could be overstressed. Thus, BDA and Associated have prepared a grouting and testing program to meet a Type II installation.

The repair plans prepared by BDA show the soil below the pipe being grouted then tested to verify the pipe meets a Type 2 installation condition. A test section is required to verify pipe bedding conditions before and after grouting. Thereafter a soil testing program will be required for each pipe with the results tabulated and submitted to the Engineer for approval. The testing program will require drilling holes in the pipe to test the soil, this should be done using a micro cover meter or GPR scanner to locate and not drill into the pipe reinforcing steel.

5. Closing

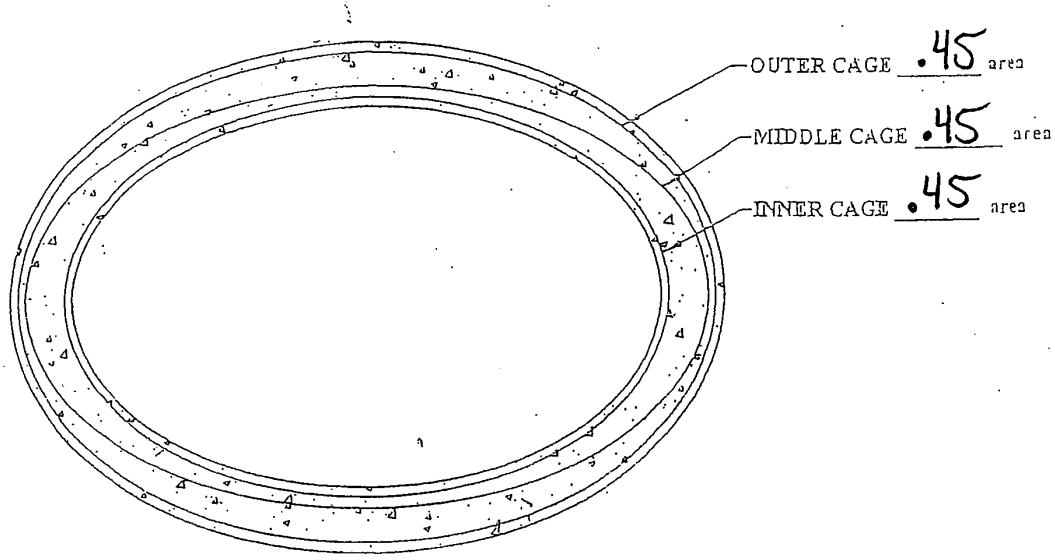
CNA observations, opinions, recommendations and analysis are based on the limited information available to us at the time of this report. We recognize that additional data, field testing, design background, and other considerations may exist but have not yet been incorporated into our considerations. We will review additional data, should such information be made available to us, and if appropriate revise our analysis, conclusions and recommendations if they are affected by the additional information.

Attachment A:

Horizontal Elliptical Pipe Shop Drawings

COUNTY MATERIALS CORPORATION

Madison (West) • 6399 Nesbitt Rd. • Madison, WI 53719
tel (608) 845-8636 • toll free (800) 601-2889 • fax (608) 845-8630
Madison (East) • 3725 Lexington Ave. • Madison, WI 53714
tel (608) 244-1381 • fax (608) 244-0656



Note 1 – The total reinforcement area of the inner cage plus the middle cage shall not be less than that specified for the inner cage in Table 1.
Note 2 – The total reinforcement area of the outer cage plus the middle cage shall not be less than that specified for the outer cage in Table 1.

Manufacturing Specifications

ASTM- C507 - other AASHTO M207
Size 68×106 84"HE Class 3

Testing

A.S.T.M. C-497 at request of engineer

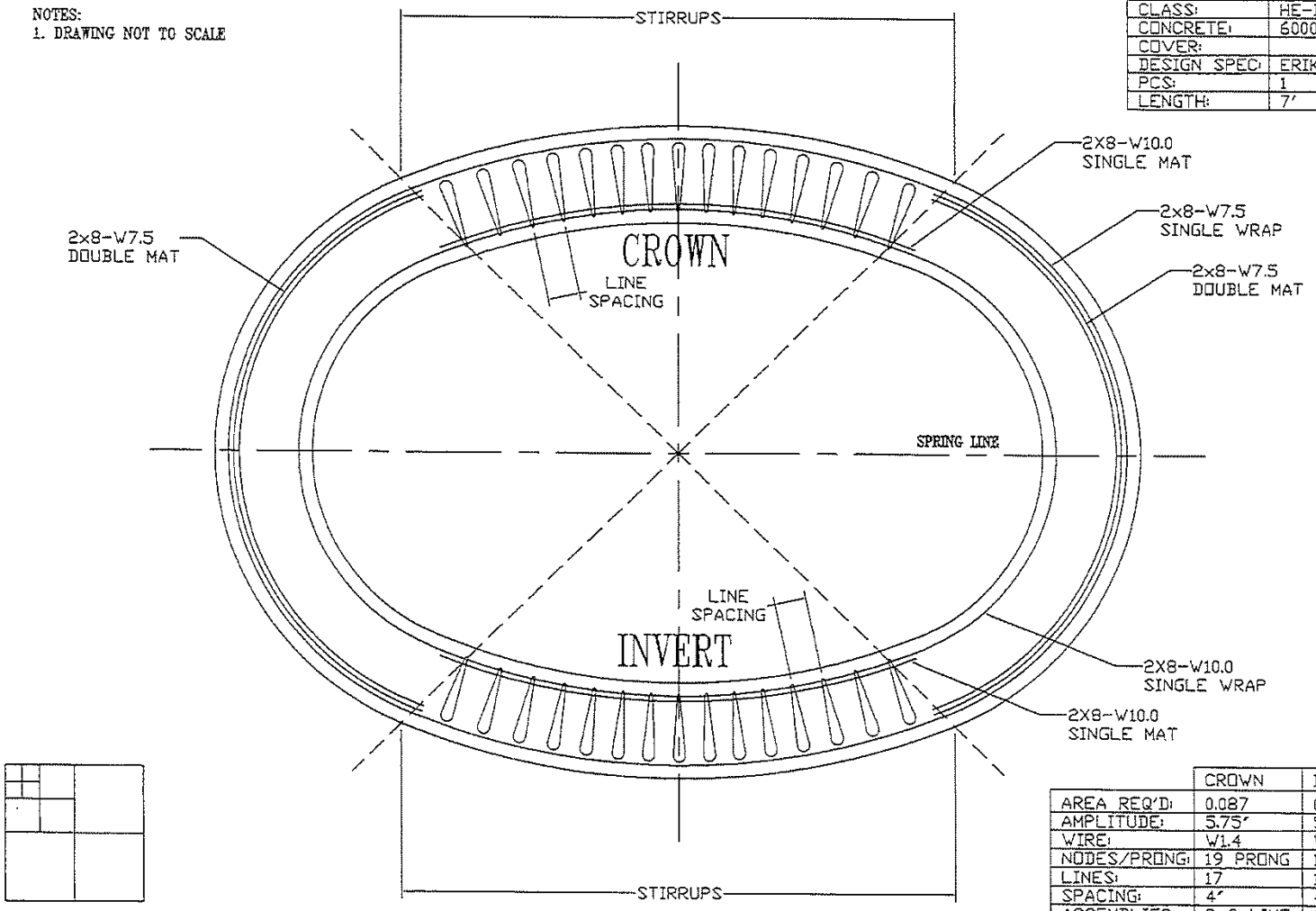
Wire Design

Inside Cage AREA .45
Middle Cage AREA .45
Outside Cage AREA .45
Pipe to be installed as shown above *

Mix design - 5000 P.S.I.

NOTES:
1. DRAWING NOT TO SCALE

DIA:	84"(68x106)
WALL:	8.5"
CLASS:	HE-IV
CONCRETE:	6000 PSI
COVER:	
DESIGN SPEC:	ERIKSSON
PCS:	1
LENGTH:	7'



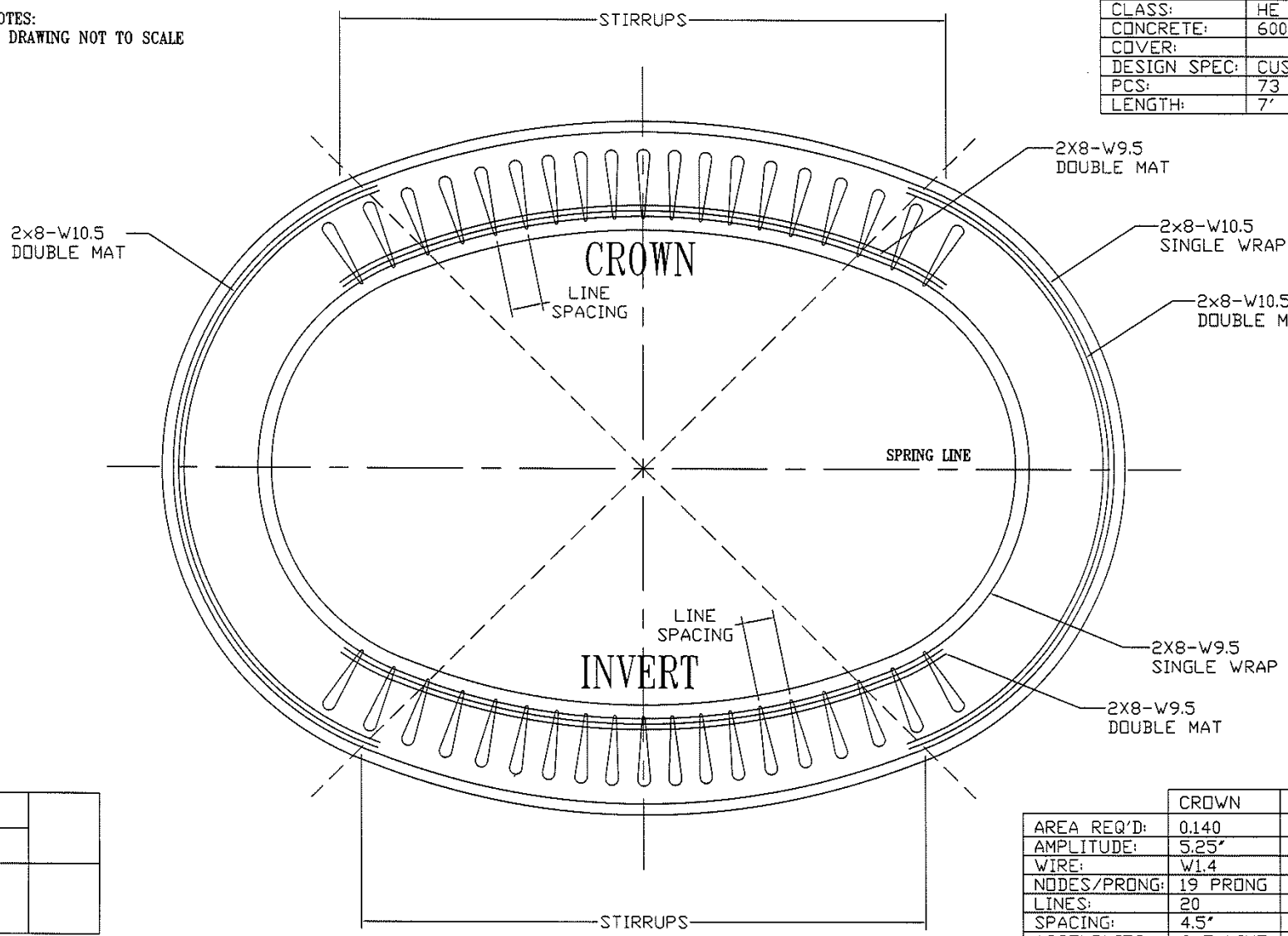
	CROWN	INVERT
AREA REQ'D:	0.087	0.087
AMPLITUDE:	5.75"	5.75"
WIRE:	W1.4	W1.4
NODES/PRONG:	19 PRONG	19 PRONG
LINES:	17	17
SPACING:	4"	4"
ASSEMBLIES:	2-9 LINE	2-9 LINE
ASSEMBLIES:	2-8 LINE	2-8 LINE

ENGINEERED WIRE PRODUCTS, INC. | CUSTOMER COUNTY MATERIALS | DRAWN BY BLB

DESCRIPTION 84"(68x106) HE-IV 6000 PSI | DATE 19SEPT17

NOTES:
1. DRAWING NOT TO SCALE

DIA:	84"(68x106)
WALL:	8.5"
CLASS:	HE D-2652
CONCRETE:	6000 PSI
COVER:	
DESIGN SPEC:	CUST SPEC
PCS:	73
LENGTH:	7'



	CROWN	INVERT
AREA REQ'D:	0.140	0.140
AMPLITUDE:	5.25"	5.25"
WIRE:	W1.4	W1.4
NODES/PRONG:	19 PRONG	19 PRONG
LINES:	20	20
SPACING:	4.5"	4.5"
ASSEMBLIES:	6-7 LINE	6-7 LINE
ASSEMBLIES:		

ENGINEERED WIRE PRODUCTS, INC. | CUSTOMER COUNTY MATERIALS | DRAWN BY BLB

DESCRIPTION 84"(68x106) HE D-2652 ULT-3554 6000 PSI | DATE 07MAR18

Attachment B:

Eriksson Pipe Output for Class III

Licensee: CNA Consulting Engineers Sht:___of___
Eriksson Pipe v.1.2 By:CRE Chk:___
Copyright © 2016-17 Eriksson Software (ErikssonSoftware.com) 12/3/2019 2:04:21 PM
Filename: page 1 of 1

Project Name: Raymond Rd Storm Tunnel
Client:
Job Information: Existing Pipe Analysis
Job Number: WisDOT 19-01
Designer: CRE

THREE-EDGE BEARING - D-LOAD ANALYSIS
106INCH SPAN HELLIPT PIPE

****

S P E C I F I E D R E I N F O R C I N G A R E A S

INSIDE REINFORCING AREA, Asi = .9 SQ.IN./FT

C A P A C I T Y R E D U C T I O N F A C T O R S

PhiF = .95 PhiC = .95 PhiD = .9 PhiR = .9

D E S I G N C O E F F I C I E N T S

Cm = 1.06 Cmo = .89 Cs = 1. Cx = 1. Cmp = 1.2

P I P E S P E C I F I C A T I O N S

Wall Thickness (in)	8.50
Inside Reinforcing Cover (in)	1.00
Outside Reinforcing Cover (in)	1.00
No. of Reinforcing Layers	1.
Pipe Weight (lbs/ft)	2725.
Concrete Strength (ksi)	6.
Reinforcing Yield Strength (ksi)	65.
Reinforcing Ultimate Strength (ksi)	75.
Design Criteria	ULTIMATE
Spacing of Circumferential Reinf. (in)	2.00

TYPE 2 REINFORCEMENT
WELDED SMOOTH WIRE FABRIC, 8 INCH MAX. SPACING OF LONGITUDINALS

C A L C U L A T E D D - L O A D C A P A C I T I E S

D-Load Based on Ultimate Flexure (Collapse) - (lbs/ft/ft)	3425.5
D-Load Based on 0.01 inch Crack - (LBS/FT/FT)	1526.2
D-Load Based on Diagonal Tension - (LBS/FT/FT)	2129.9
D-Load Based on Radial Tension - (LBS/FT/FT)	3561.3

This analysis of D-load capacity is based solely on the inside reinforcing. Outside reinforcing is normally provided as a fraction of the inside reinforcing. The user should reference appropriate ASTM Standards for the appropriate criteria. The most common standards are ASTM C 76 for circular pipe, ASTM C 506 for arch pipe and ASTM C 507 for elliptical pipe.

Attachment C:

Eriksson Pipe Output for Class IV

Project Name: Raymond Rd Storm Tunnel
Client:
Job Information: Existing Pipe Analysis
Job Number: WisDOT 19-01
Designer: CRE

THREE-EDGE BEARING - REINFORCING DESIGN
106INCH SPAN HELLIPT PIPE

****

S P E C I F I E D D - L O A D S

DL.01 = 2000 LBS/FT/FT DLult = 3000 LBS/FT/FT

C A P A C I T Y R E D U C T I O N F A C T O R S

PhiF = .95 PhiC = .95 PhiD = .9 PhiR = .9

D E S I G N C O E F F I C I E N T S

Cm = 1.06 Cmo = .89 Cs = 1. Cx = 1. Cmp = 1.21

P I P E S P E C I F I C A T I O N S

Wall Thickness (in)	8.50
Inside Reinforcing Cover (in)	1.00
Outside Reinforcing Cover (in)	1.00
No. of Reinforcing Layers	1.
Pipe Weight (lbs/ft)	2725.
Concrete Strength (ksi)	6.
Reinforcing Yield Strength (ksi)	65.
Reinforcing Ultimate Strength (ksi)	75.
Developable Stirrup Stress (ksi)	60.
Design Criteria	ULTIMATE
Spacing of Circumferential Reinf. (in)	2.00

TYPE 3 REINFORCEMENT
WELDED DEFORMED WIRE FABRIC, DEFORMED BARS
OR ANY REINFORCEMENT WITH STIRRUPS

R E I N F O R C I N G D E S I G N C R I T E R I A

FLEXURE STEEL AREA (ULTIMATE) - (SQ.IN./FT)	.796
0.01 INCH CRACK STEEL AREA - (SQ.IN./FT)	1.163
0.01 INCH CRACK STEEL AREA WITH TYPE 3 REINF. - (SQ.IN./FT)	1.163

DIAGONAL TENSION REINF. EXCEEDS 0.02 bd, STIRRUPS ARE REQUIRED

MAXIMUM RADIAL TENSION D-LOAD - (LBS/FT/FT)	3498

G O V E R N I N G R E I N F O R C I N G D E S I G N

INNER REINFORCING AREA - (SQ.IN./FT)	1.163
OUTER REINFORCING AREA - (SQ.IN./FT)	1.163

STIRRUPS ARE REQUIRED AT THE CROWN AND INVERT

REQUIRED STIRRUP AREA - (SQ.IN./FT/LINE)	.088
REQUIRED STIRRUP SPACING AND EXTENT	17 LINES AT 4. IN.

Project Name: Raymond Rd Storm Tunnel
Client:
Job Information: Existing Pipe Analysis
Job Number: WisDOT 19-01
Designer: CRE

THREE-EDGE BEARING - D-LOAD ANALYSIS
106INCH SPAN HELLIPT PIPE

****

S P E C I F I E D R E I N F O R C I N G A R E A S

INSIDE REINFORCING AREA, Asi = 1.2 SQ.IN./FT

C A P A C I T Y R E D U C T I O N F A C T O R S

PhiF = .95 PhiC = .95 PhiD = .9 PhiR = .9

D E S I G N C O E F F I C I E N T S

Cm = 1.06 Cmo = .89 Cs = 1. Cx = 1. Cmp = 1.2

P I P E S P E C I F I C A T I O N S

Wall Thickness (in)	8.50
Inside Reinforcing Cover (in)	1.00
Outside Reinforcing Cover (in)	1.00
No. of Reinforcing Layers	1.
Pipe Weight (lbs/ft)	2725.
Concrete Strength (ksi)	6.
Reinforcing Yield Strength (ksi)	65.
Reinforcing Ultimate Strength (ksi)	75.
Design Criteria	ULTIMATE
Spacing of Circumferential Reinf. (in)	2.00

TYPE 3 REINFORCEMENT
WELDED DEFORMED WIRE FABRIC, DEFORMED BARS
OR ANY REINFORCEMENT WITH STIRRUPS

C A L C U L A T E D D - L O A D C A P A C I T I E S

D-Load Based on Ultimate Flexure (Collapse) - (lbs/ft/ft)	4497.1
D-Load Based on 0.01 inch Crack - (LBS/FT/FT)	2064.0
D-Load Based on Diagonal Tension - (LBS/FT/FT)	2423.5
D-Load Based on Radial Tension - (LBS/FT/FT)	3543.7

This analysis of D-load capacity is based solely on the inside reinforcing. Outside reinforcing is normally provided as a fraction of the inside reinforcing. The user should reference appropriate ASTM Standards for the appropriate criteria. The most common standards are ASTM C 76 for circular pipe, ASTM C 506 for arch pipe and ASTM C 507 for elliptical pipe.

Attachment D:

Eriksson Pipe Output for Class Special

Licensee: CNA Consulting Engineers
Eriksson Pipe v.1.2
Copyright © 2016-17 Eriksson Software (ErikssonSoftware.com)
Filename:

Sht:___of___
By:CRE Chk:___
12/3/2019 2:10:31 PM
page 1 of 1

Project Name: Raymond Rd Storm Tunnel
Client:
Job Information: Existing Pipe Analysis
Job Number: WisDOT 19-01
Designer: CRE

THREE-EDGE BEARING - D-LOAD ANALYSIS
106INCH SPAN HELLIPT PIPE

****

S P E C I F I E D R E I N F O R C I N G A R E A S

INSIDE REINFORCING AREA, Asi = 1.71 SQ.IN./FT

C A P A C I T Y R E D U C T I O N F A C T O R S

PhiF = .95 PhiC = .95 PhiD = .9 PhiR = .9

D E S I G N C O E F F I C I E N T S

Cm = 1.06 Cmo = .89 Cs = 1. Cx = 1. Cmp = 1.21

P I P E S P E C I F I C A T I O N S

Wall Thickness (in)	8.50
Inside Reinforcing Cover (in)	1.00
Outside Reinforcing Cover (in)	1.00
No. of Reinforcing Layers	1.
Pipe Weight (lbs/ft)	2725.
Concrete Strength (ksi)	6.
Reinforcing Yield Strength (ksi)	65.
Reinforcing Ultimate Strength (ksi)	75.
Developable Stirrup Stress (ksi)	60.
Design Criteria	ULTIMATE
Spacing of Circumferential Reinf. (in)	2.00

TYPE 3 REINFORCEMENT
WELDED DEFORMED WIRE FABRIC, DEFORMED BARS
OR ANY REINFORCEMENT WITH STIRRUPS

C A L C U L A T E D D - L O A D C A P A C I T I E S

D-Load Based on Ultimate Flexure (Collapse) - (lbs/ft/ft)	6153.1
D-Load Based on 0.01 inch Crack - (LBS/FT/FT)	2693.4
D-Load Based on Diagonal Tension - (LBS/FT/FT)	2925.1
D-Load Based on Radial Tension - (LBS/FT/FT)	3518.2

This analysis of D-load capacity is based solely on the inside reinforcing. Outside reinforcing is normally provided as a fraction of the inside reinforcing. The user should reference appropriate ASTM Standards for the appropriate criteria. The most common standards are ASTM C 76 for circular pipe, ASTM C 506 for arch pipe and ASTM C 507 for elliptical pipe.

Attachment E:

PipePac Output

Three Edge Bearing Analysis - Results

Project Description

Project Title: WisDOT
Project Location: Madison,WI
Contract Number:
Country: US
Units: US Units
Alternative: p=0.9

Consultant: CNA Engineers
Contractor:
Analyzed By: CRE
Date: 11/14/2019
Comply To: ASTM (AASHTO)

D-LOAD REQUIREMENTS FOR A 106 (in) SPAN HORIZONTAL ELLIPTICAL PIPE

PIPE DATA

Span (in.)	106
Rise (in.)	68
Wall Thickness (in.)	8.500

INSTALLATION CONDITIONS

Minimum Depth of Fill (ft)	10.00
Maxmum Depth of Fill (ft)	35.00
Soil Density (lb/cu. ft)	120.0
Installation Type	Positive Projecting Embankment
Positive Projection Ratio	0.90
Soil Lateral Pressure Ratio	0.33
Soil Lateral Pressure/Friction Term (kμ)	0.165
Soil Lateral Fraction 'm'	0.90
Settlement Ratio	0.70

ADDITIONAL LOADS

No Live or Surcharge Loads

Fluid Load (lb/ft)	2453

FACTOR OF SAFETY

Factor of Safety on 0.01 Inch Crack D-Load (Earth, Live)	1.00 1.00
Factor of Safety on Ultimate Earth and Live Load (ASTM C 76)	
DL.01 Less Than or Equal To 2000 lbs/ft/ft	1.50
DL.01 Greater Than or Equal To 3000 lbs/ft/ft	1.25
DL.01 Between 2000 and 3000 lbs/ft/ft	Interpolated

D-LOAD REQUIREMENTS FOR 106 in. SPAN HORIZONTAL ELLIPTICAL PIPE
Results of Analysis for Bedding Type 2

Pipe Depth	Arching Factor	Earth Load (lb/ft)	Live Load (lb/ft)	Surch Load (lb/ft)	Total Load (lb/ft)	Bed Fact DL	Bed Fact LL	Required D-Load 0.01 in. (lb/ft/ft)
10.00	**1.18**	**14511**	**0**	**0**	**16964**	**2.51**	**2.20**	**766 (CL-I)**
11.00	**1.20**	**16236**	**0**	**0**	**18689**	**2.49**	**2.20**	**850 (CL-II)**
12.00	1.22	18017	0	0	20470	2.47	2.20	937 (CL-II)
13.00	**1.24**	**19856**	**0**	**0**	**22309**	**2.46**	**2.20**	**1026 (CL-III)**
14.00	1.26	21756	0	0	24209	2.45	2.20	1119 (CL-III)
15.00	1.29	23718	0	0	26171	2.44	2.20	1215 (CL-III)
16.00	1.31	25744	0	0	28197	2.43	2.20	1315 (CL-III)
17.00	**1.33**	**27836**	**0**	**0**	**30289**	**2.42**	**2.20**	**1418 (CL-IV)**
18.00	1.35	29997	0	0	32450	2.41	2.20	1525 (CL-IV)
19.00	1.38	32228	0	0	34682	2.40	2.20	1635 (CL-IV)
20.00	1.40	34349	0	0	36802	2.39	2.20	1740 (CL-IV)
21.00	1.40	36147	0	0	38600	2.39	2.20	1827 (CL-IV)
22.00	1.40	37928	0	0	40381	2.39	2.20	1913 (CL-IV)
23.00	1.40	39708	0	0	42161	2.39	2.20	1999 (CL-IV)
24.00	**1.41**	**41521**	**0**	**0**	**43975**	**2.39**	**2.20**	**2087 (CL-V)**
25.00	1.41	43299	0	0	45752	2.38	2.20	2173 (CL-V)
26.00	1.41	45076	0	0	47529	2.38	2.20	2258 (CL-V)
27.00	1.41	46852	0	0	49306	2.38	2.20	2344 (CL-V)
28.00	1.41	48628	0	0	51082	2.38	2.20	2430 (CL-V)
29.00	1.41	50404	0	0	52857	2.38	2.20	2516 (CL-V)
30.00	1.41	52180	0	0	54633	2.38	2.20	2602 (CL-V)
31.00	1.42	53954	0	0	56408	2.38	2.20	2687 (CL-V)
32.00	1.42	55729	0	0	58182	2.38	2.20	2773 (CL-V)
33.00	1.42	57503	0	0	59957	2.37	2.20	2859 (CL-V)
34.00	1.42	59278	0	0	61731	2.37	2.20	2944 (CL-V)
35.00	**1.42**	**61051**	**0**	**0**	**63505**	**2.37**	**2.20**	**3030 (3030-D)**

Selected Depth: 0 ft. (closest pipe depth: 0 ft)

(N/A) = SAMM analysis is not accurate at this depth use direct analysis for more accurate results.

(i.e. Bedding Types 2 or 3)
Fluid Load (2453 lbs/ft) included in the calculation of the Total Load

D-LOAD REQUIREMENTS FOR 106 in. SPAN HORIZONTAL ELLIPTICAL PIPE
Results of Analysis for Bedding Type 3

Pipe Depth	Arching Factor	Earth Load (lb/ft)	Live Load (lb/ft)	Surch Load (lb/ft)	Total Load (lb/ft)	Bed Fact DL	Bed Fact LL	Required D-Load 0.01 in. (lb/ft/ft)
10.00	**1.18**	**14511**	**0**	**0**	**16964**	**2.01**	**2.01**	**957 (CL-II)**
11.00	**1.20**	**16236**	**0**	**0**	**18689**	**2.00**	**2.00**	**1060 (CL-III)**
12.00	1.22	18017	0	0	20470	1.99	1.99	1167 (CL-III)
13.00	1.24	19856	0	0	22309	1.98	1.98	1278 (CL-III)
14.00	**1.26**	**21756**	**0**	**0**	**24209**	**1.97**	**1.97**	**1392 (CL-IV)**
15.00	1.29	23718	0	0	26171	1.96	1.96	1510 (CL-IV)
16.00	1.31	25744	0	0	28197	1.96	1.96	1633 (CL-IV)
17.00	1.33	27836	0	0	30289	1.95	1.95	1759 (CL-IV)
18.00	1.35	29997	0	0	32450	1.94	1.94	1890 (CL-IV)
19.00	**1.38**	**32228**	**0**	**0**	**34682**	**1.94**	**1.94**	**2026 (CL-V)**
20.00	1.40	34349	0	0	36802	1.93	1.93	2154 (CL-V)
21.00	1.40	36147	0	0	38600	1.93	1.93	2261 (CL-V)
22.00	1.40	37928	0	0	40381	1.93	1.93	2368 (CL-V)
23.00	1.40	39708	0	0	42161	1.93	1.93	2474 (CL-V)
24.00	1.41	41521	0	0	43975	1.93	1.93	2582 (CL-V)
25.00	1.41	43299	0	0	45752	1.93	1.93	2688 (CL-V)
26.00	1.41	45076	0	0	47529	1.93	1.93	2794 (CL-V)
27.00	1.41	46852	0	0	49306	1.93	1.93	2900 (CL-V)
28.00	**1.41**	**48628**	**0**	**0**	**51082**	**1.92**	**1.92**	**3005 (3005-D)**
29.00	**1.41**	**50404**	**0**	**0**	**52857**	**1.92**	**1.92**	**3111 (3111-D)**
30.00	**1.41**	**52180**	**0**	**0**	**54633**	**1.92**	**1.92**	**3217 (3217-D)**
31.00	**1.42**	**53954**	**0**	**0**	**56408**	**1.92**	**1.92**	**3323 (3323-D)**
32.00	**1.42**	**55729**	**0**	**0**	**58182**	**1.92**	**1.92**	**3428 (3428-D)**
33.00	**1.42**	**57503**	**0**	**0**	**59957**	**1.92**	**1.92**	**3534 (3534-D)**

34.00	**1.42**	**59278**	**0**	**0**	**61731**	**1.92**	**1.92**	**3640 (3640-D)**
35.00	**1.42**	**61051**	**0**	**0**	**63505**	**1.92**	**1.92**	**3745 (3745-D)**

Selected Depth: 0 ft. (closest pipe depth: 0 ft)
(N/A) = SAMM analysis is not accurate at this depth use direct analysis for more accurate results.
(i.e. Bedding Types 2 or 3)
Fluid Load (2453 lbs/ft) included in the calculation of the Total Load

Pipe Analysis Report

Pipe Depth – The height of cover from the top of the pipe to the soil surface, m (ft).

Earth Load

Arching Factor – The ratio of the design soil load on the pipe to the load from the prism of soil immediately above the pipe (prism load). By multiplying the soil prism load by the Arching Factor, the Earth Load on the pipe will be determined. The Arching Factor is constant for Standard Installations in the positive projecting condition, but variable for all other bedding and installation conditions.

>Trans - (Applicable for Trench and Negative Projecting Conditions only) – When a trench or negative projecting design is performed, the soil load above the pipe may or may not be reduced by frictional forces between the insitu and placed soils, depending on the depth and width of the trench. A symbol of "Y" is shown when the trench width exceeds the width at which frictional forces reduce the soil load on the pipe (Yes, the transition width has been exceeded, and the positive projecting design governs). A symbol of "N" is shown if frictional forces reduce the load on the pipe (No, the transition width has not been exceeded).

Load – The load in kN/m (lbs/ft) imposed on the pipe from the soil.

Live Load – The load on the pipe resulting from a dynamic load at the surface, kN/m (lbs/ft).

Surcharge Load – The load in kN/m (lbs/ft) imposed on the pipe from surcharge loads such as buildings, stationary equipment, etc. on the soil surface above the pipe.

Total Load – The summation of all the loads on the pipe. This would include when applicable; Earth Load + Surcharge Load + Live Load + Fluid Load.

Note: Since the internal fluid load for a pipe is constant regardless of fill height it is not listed in the table. When the user chooses to consider fluid load, it is written below the table and included in the total load.

Bedding Factor

DL – The dead load bedding factor applied to the pipe at that depth. The higher the bedding factor, the greater the support that is given to the pipe by the surrounding soil. This factor is divided by the Total Load for the B, C, and D beddings only.

LL – The live load bedding factor applied to the pipe at that depth. The live load bedding factor accounts for concentrated loads resulting from live loads over pipe with shallow cover. For the Type 1, 2, 3, 4 and Jacking Installations the Live Load is divided by the lower of this value or the DL value, and all other loads are summed up and divided by the DL value.

Required D-Load 0.3mm (0.01 in) – The load the pipe is required to support in the three-edge bearing test with a crack equal to or less than 0.3 mm (0.01 in) which equates to the maximum stress induced on the pipe in the installed condition. The load is given in kN (lbs) per m (ft) length of pipe per mm (ft) of diameter (or span for noncircular pipe).

Required TEB-Load Ultimate – The load that the pipe is required to be able to support in the three-edge bearing test prior to failure. The load is given in kN (lbs) per m (ft) length of pipe.

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Use of this program consitutes acceptance of this liability agreement by the user.

Three Edge Bearing Analysis - Results

Project Description

Project Title: WisDOT
Project Location: Madison,WI
Contract Number:
Country: US
Units: US Units
Alternative: p=0.7

Consultant: CNA Engineers
Contractor:
Analyzed By: CRE
Date: 11/14/2019
Comply To: ASTM (AASHTO)

D-LOAD REQUIREMENTS FOR A 106 (in) SPAN HORIZONTAL ELLIPTICAL PIPE

PIPE DATA

Span (in.)	106
Rise (in.)	68
Wall Thickness (in.)	8.500

INSTALLATION CONDITIONS

Minimum Depth of Fill (ft)	10.00
Maxmum Depth of Fill (ft)	35.00
Soil Density (lb/cu. ft)	120.0
Installation Type	Positive Projecting Embankment
Positive Projection Ratio	0.70
Soil Lateral Pressure Ratio	0.33
Soil Lateral Pressure/Friction Term (kμ)	0.165
Soil Lateral Fraction 'm'	0.70
Settlement Ratio	0.70

ADDITIONAL LOADS

No Live or Surcharge Loads

Fluid Load (lb/ft)	2453

FACTOR OF SAFETY

Factor of Safety on 0.01 Inch Crack D-Load (Earth, Live)	1.00 1.00
Factor of Safety on Ultimate Earth and Live Load (ASTM C 76)	
DL.01 Less Than or Equal To 2000 lbs/ft/ft	1.50
DL.01 Greater Than or Equal To 3000 lbs/ft/ft	1.25
DL.01 Between 2000 and 3000 lbs/ft/ft	Interpolated

D-LOAD REQUIREMENTS FOR 106 in. SPAN HORIZONTAL ELLIPTICAL PIPE
Results of Analysis for Bedding Type 2

Pipe Depth	Arching Factor	Earth Load (lb/ft)	Live Load (lb/ft)	Surch Load (lb/ft)	Total Load (lb/ft)	Bed Fact DL	Bed Fact LL	Required D-Load 0.01 in. (lb/ft/ft)
10.00	**1.18**	**14511**	**0**	**0**	**16964**	**2.51**	**2.20**	**766 (CL-I)**
11.00	**1.20**	**16236**	**0**	**0**	**18689**	**2.49**	**2.20**	**850 (CL-II)**
12.00	1.22	18017	0	0	20470	2.47	2.20	937 (CL-II)
13.00	**1.24**	**19856**	**0**	**0**	**22309**	**2.46**	**2.20**	**1026 (CL-III)**
14.00	1.26	21756	0	0	24209	2.45	2.20	1119 (CL-III)
15.00	1.29	23718	0	0	26171	2.44	2.20	1215 (CL-III)
16.00	1.31	25744	0	0	28197	2.43	2.20	1315 (CL-III)
17.00	**1.33**	**27836**	**0**	**0**	**30289**	**2.42**	**2.20**	**1418 (CL-IV)**
18.00	1.35	29997	0	0	32450	2.41	2.20	1525 (CL-IV)
19.00	1.38	32228	0	0	34682	2.40	2.20	1635 (CL-IV)
20.00	1.40	34349	0	0	36802	2.39	2.20	1740 (CL-IV)
21.00	1.40	36147	0	0	38600	2.39	2.20	1827 (CL-IV)
22.00	1.40	37928	0	0	40381	2.39	2.20	1913 (CL-IV)
23.00	1.40	39708	0	0	42161	2.39	2.20	1999 (CL-IV)
24.00	**1.41**	**41521**	**0**	**0**	**43975**	**2.39**	**2.20**	**2087 (CL-V)**
25.00	1.41	43299	0	0	45752	2.38	2.20	2173 (CL-V)
26.00	1.41	45076	0	0	47529	2.38	2.20	2258 (CL-V)
27.00	1.41	46852	0	0	49306	2.38	2.20	2344 (CL-V)
28.00	1.41	48628	0	0	51082	2.38	2.20	2430 (CL-V)
29.00	1.41	50404	0	0	52857	2.38	2.20	2516 (CL-V)
30.00	1.41	52180	0	0	54633	2.38	2.20	2602 (CL-V)
31.00	1.42	53954	0	0	56408	2.38	2.20	2687 (CL-V)
32.00	1.42	55729	0	0	58182	2.38	2.20	2773 (CL-V)
33.00	1.42	57503	0	0	59957	2.37	2.20	2859 (CL-V)
34.00	1.42	59278	0	0	61731	2.37	2.20	2944 (CL-V)
35.00	**1.42**	**61051**	**0**	**0**	**63505**	**2.37**	**2.20**	**3030 (3030-D)**

Selected Depth: 0 ft. (closest pipe depth: 0 ft)

(N/A) = SAMM analysis is not accurate at this depth use direct analysis for more accurate results.

(i.e. Bedding Types 2 or 3)
Fluid Load (2453 lbs/ft) included in the calculation of the Total Load

D-LOAD REQUIREMENTS FOR 106 in. SPAN HORIZONTAL ELLIPTICAL PIPE
Results of Analysis for Bedding Type 3

Pipe Depth	Arching Factor	Earth Load (lb/ft)	Live Load (lb/ft)	Surch Load (lb/ft)	Total Load (lb/ft)	Bed Fact DL	Bed Fact LL	Required D-Load 0.01 in. (lb/ft/ft)
10.00	**1.18**	**14511**	**0**	**0**	**16964**	**2.01**	**2.01**	**957 (CL-II)**
11.00	**1.20**	**16236**	**0**	**0**	**18689**	**2.00**	**2.00**	**1060 (CL-III)**
12.00	1.22	18017	0	0	20470	1.99	1.99	1167 (CL-III)
13.00	1.24	19856	0	0	22309	1.98	1.98	1278 (CL-III)
14.00	**1.26**	**21756**	**0**	**0**	**24209**	**1.97**	**1.97**	**1392 (CL-IV)**
15.00	1.29	23718	0	0	26171	1.96	1.96	1510 (CL-IV)
16.00	1.31	25744	0	0	28197	1.96	1.96	1633 (CL-IV)
17.00	1.33	27836	0	0	30289	1.95	1.95	1759 (CL-IV)
18.00	1.35	29997	0	0	32450	1.94	1.94	1890 (CL-IV)
19.00	**1.38**	**32228**	**0**	**0**	**34682**	**1.94**	**1.94**	**2026 (CL-V)**
20.00	1.40	34349	0	0	36802	1.93	1.93	2154 (CL-V)
21.00	1.40	36147	0	0	38600	1.93	1.93	2261 (CL-V)
22.00	1.40	37928	0	0	40381	1.93	1.93	2368 (CL-V)
23.00	1.40	39708	0	0	42161	1.93	1.93	2474 (CL-V)
24.00	1.41	41521	0	0	43975	1.93	1.93	2582 (CL-V)
25.00	1.41	43299	0	0	45752	1.93	1.93	2688 (CL-V)
26.00	1.41	45076	0	0	47529	1.93	1.93	2794 (CL-V)
27.00	1.41	46852	0	0	49306	1.93	1.93	2900 (CL-V)
28.00	**1.41**	**48628**	**0**	**0**	**51082**	**1.92**	**1.92**	**3005 (3005-D)**
29.00	**1.41**	**50404**	**0**	**0**	**52857**	**1.92**	**1.92**	**3111 (3111-D)**
30.00	**1.41**	**52180**	**0**	**0**	**54633**	**1.92**	**1.92**	**3217 (3217-D)**
31.00	**1.42**	**53954**	**0**	**0**	**56408**	**1.92**	**1.92**	**3323 (3323-D)**
32.00	**1.42**	**55729**	**0**	**0**	**58182**	**1.92**	**1.92**	**3428 (3428-D)**
33.00	**1.42**	**57503**	**0**	**0**	**59957**	**1.92**	**1.92**	**3534 (3534-D)**

34.00	**1.42**	**59278**	**0**	**0**	**61731**	**1.92**	**1.92**	**3640 (3640-D)**
35.00	**1.42**	**61051**	**0**	**0**	**63505**	**1.92**	**1.92**	**3745 (3745-D)**

Selected Depth: 0 ft. (closest pipe depth: 0 ft)
(N/A) = SAMM analysis is not accurate at this depth use direct analysis for more accurate results.
(i.e. Bedding Types 2 or 3)
Fluid Load (2453 lbs/ft) included in the calculation of the Total Load

Pipe Analysis Report

Pipe Depth – The height of cover from the top of the pipe to the soil surface, m (ft).

Earth Load

Arching Factor – The ratio of the design soil load on the pipe to the load from the prism of soil immediately above the pipe (prism load). By multiplying the soil prism load by the Arching Factor, the Earth Load on the pipe will be determined. The Arching Factor is constant for Standard Installations in the positive projecting condition, but variable for all other bedding and installation conditions.

>Trans - (Applicable for Trench and Negative Projecting Conditions only) – When a trench or negative projecting design is performed, the soil load above the pipe may or may not be reduced by frictional forces between the insitu and placed soils, depending on the depth and width of the trench. A symbol of "Y" is shown when the trench width exceeds the width at which frictional forces reduce the soil load on the pipe (Yes, the transition width has been exceeded, and the positive projecting design governs). A symbol of "N" is shown if frictional forces reduce the load on the pipe (No, the transition width has not been exceeded).

Load – The load in kN/m (lbs/ft) imposed on the pipe from the soil.

Live Load – The load on the pipe resulting from a dynamic load at the surface, kN/m (lbs/ft).

Surcharge Load – The load in kN/m (lbs/ft) imposed on the pipe from surcharge loads such as buildings, stationary equipment, etc. on the soil surface above the pipe.

Total Load – The summation of all the loads on the pipe. This would include when applicable; Earth Load + Surcharge Load + Live Load + Fluid Load.

Note: Since the internal fluid load for a pipe is constant regardless of fill height it is not listed in the table. When the user chooses to consider fluid load, it is written below the table and included in the total load.

Bedding Factor

DL – The dead load bedding factor applied to the pipe at that depth. The higher the bedding factor, the greater the support that is given to the pipe by the surrounding soil. This factor is divided by the Total Load for the B, C, and D beddings only.

LL – The live load bedding factor applied to the pipe at that depth. The live load bedding factor accounts for concentrated loads resulting from live loads over pipe with shallow cover. For the Type 1, 2, 3, 4 and Jacking Installations the Live Load is divided by the lower of this value or the DL value, and all other loads are summed up and divided by the DL value.

Required D-Load 0.3mm (0.01 in) – The load the pipe is required to support in the three-edge bearing test with a crack equal to or less than 0.3 mm (0.01 in) which equates to the maximum stress induced on the pipe in the installed condition. The load is given in kN (lbs) per m (ft) length of pipe per mm (ft) of diameter (or span for noncircular pipe).

Required TEB-Load Ultimate – The load that the pipe is required to be able to support in the three-edge bearing test prior to failure. The load is given in kN (lbs) per m (ft) length of pipe.

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Three Edge Bearing Analysis - Results

Project Description

Project Title: WisDOT
Project Location: Madison,WI
Contract Number:
Country: US
Units: US Units
Alternative: p=0.5

Consultant: CNA Engineers
Contractor:
Analyzed By: CRE
Date: 11/14/2019
Comply To: ASTM (AASHTO)

D-LOAD REQUIREMENTS FOR A 106 (in) SPAN HORIZONTAL ELLIPTICAL PIPE

PIPE DATA

Span (in.)	106
Rise (in.)	68
Wall Thickness (in.)	8.500

INSTALLATION CONDITIONS

Minimum Depth of Fill (ft)	10.00
Maxmum Depth of Fill (ft)	35.00
Soil Density (lb/cu. ft)	120.0
Installation Type	Positive Projecting Embankment
Positive Projection Ratio	0.50
Soil Lateral Pressure Ratio	0.33
Soil Lateral Pressure/Friction Term (kμ)	0.165
Soil Lateral Fraction 'm'	0.50
Settlement Ratio	0.70

ADDITIONAL LOADS

No Live or Surcharge Loads

Fluid Load (lb/ft)	2453

FACTOR OF SAFETY

Factor of Safety on 0.01 Inch Crack D-Load (Earth, Live)	1.00 1.00
Factor of Safety on Ultimate Earth and Live Load (ASTM C 76)	
DL.01 Less Than or Equal To 2000 lbs/ft/ft	1.50
DL.01 Greater Than or Equal To 3000 lbs/ft/ft	1.25
DL.01 Between 2000 and 3000 lbs/ft/ft	Interpolated

D-LOAD REQUIREMENTS FOR 106 in. SPAN HORIZONTAL ELLIPTICAL PIPE
Results of Analysis for Bedding Type 2

Pipe Depth	Arching Factor	Earth Load (lb/ft)	Live Load (lb/ft)	Surch Load (lb/ft)	Total Load (lb/ft)	Bed Fact DL	Bed Fact LL	Required D-Load 0.01 in. (lb/ft/ft)
10.00	**1.18**	**14511**	**0**	**0**	**16964**	**2.51**	**2.20**	**766 (CL-I)**
11.00	**1.20**	**16236**	**0**	**0**	**18689**	**2.49**	**2.20**	**850 (CL-II)**
12.00	1.22	18017	0	0	20470	2.47	2.20	937 (CL-II)
13.00	**1.24**	**19856**	**0**	**0**	**22309**	**2.46**	**2.20**	**1026 (CL-III)**
14.00	1.26	21756	0	0	24209	2.45	2.20	1119 (CL-III)
15.00	1.29	23718	0	0	26171	2.44	2.20	1215 (CL-III)
16.00	1.31	25744	0	0	28197	2.43	2.20	1315 (CL-III)
17.00	**1.33**	**27836**	**0**	**0**	**30289**	**2.42**	**2.20**	**1418 (CL-IV)**
18.00	1.35	29997	0	0	32450	2.41	2.20	1525 (CL-IV)
19.00	1.38	32228	0	0	34682	2.40	2.20	1635 (CL-IV)
20.00	1.40	34349	0	0	36802	2.39	2.20	1740 (CL-IV)
21.00	1.40	36147	0	0	38600	2.39	2.20	1827 (CL-IV)
22.00	1.40	37928	0	0	40381	2.39	2.20	1913 (CL-IV)
23.00	1.40	39708	0	0	42161	2.39	2.20	1999 (CL-IV)
24.00	**1.41**	**41521**	**0**	**0**	**43975**	**2.39**	**2.20**	**2087 (CL-V)**
25.00	1.41	43299	0	0	45752	2.38	2.20	2173 (CL-V)
26.00	1.41	45076	0	0	47529	2.38	2.20	2258 (CL-V)
27.00	1.41	46852	0	0	49306	2.38	2.20	2344 (CL-V)
28.00	1.41	48628	0	0	51082	2.38	2.20	2430 (CL-V)
29.00	1.41	50404	0	0	52857	2.38	2.20	2516 (CL-V)
30.00	1.41	52180	0	0	54633	2.38	2.20	2602 (CL-V)
31.00	1.42	53954	0	0	56408	2.38	2.20	2687 (CL-V)
32.00	1.42	55729	0	0	58182	2.38	2.20	2773 (CL-V)
33.00	1.42	57503	0	0	59957	2.37	2.20	2859 (CL-V)
34.00	1.42	59278	0	0	61731	2.37	2.20	2944 (CL-V)
35.00	**1.42**	**61051**	**0**	**0**	**63505**	**2.37**	**2.20**	**3030 (3030-D)**

Selected Depth: 0 ft. (closest pipe depth: 0 ft)

(N/A) = SAMM analysis is not accurate at this depth use direct analysis for more accurate results.

(i.e. Bedding Types 2 or 3)
Fluid Load (2453 lbs/ft) included in the calculation of the Total Load

D-LOAD REQUIREMENTS FOR 106 in. SPAN HORIZONTAL ELLIPTICAL PIPE
Results of Analysis for Bedding Type 3

Pipe Depth	Arching Factor	Earth Load (lb/ft)	Live Load (lb/ft)	Surch Load (lb/ft)	Total Load (lb/ft)	Bed Fact DL	Bed Fact LL	Required D-Load 0.01 in. (lb/ft/ft)
10.00	**1.18**	**14511**	**0**	**0**	**16964**	**2.01**	**2.01**	**957 (CL-II)**
11.00	**1.20**	**16236**	**0**	**0**	**18689**	**2.00**	**2.00**	**1060 (CL-III)**
12.00	1.22	18017	0	0	20470	1.99	1.99	1167 (CL-III)
13.00	1.24	19856	0	0	22309	1.98	1.98	1278 (CL-III)
14.00	**1.26**	**21756**	**0**	**0**	**24209**	**1.97**	**1.97**	**1392 (CL-IV)**
15.00	1.29	23718	0	0	26171	1.96	1.96	1510 (CL-IV)
16.00	1.31	25744	0	0	28197	1.96	1.96	1633 (CL-IV)
17.00	1.33	27836	0	0	30289	1.95	1.95	1759 (CL-IV)
18.00	1.35	29997	0	0	32450	1.94	1.94	1890 (CL-IV)
19.00	**1.38**	**32228**	**0**	**0**	**34682**	**1.94**	**1.94**	**2026 (CL-V)**
20.00	1.40	34349	0	0	36802	1.93	1.93	2154 (CL-V)
21.00	1.40	36147	0	0	38600	1.93	1.93	2261 (CL-V)
22.00	1.40	37928	0	0	40381	1.93	1.93	2368 (CL-V)
23.00	1.40	39708	0	0	42161	1.93	1.93	2474 (CL-V)
24.00	1.41	41521	0	0	43975	1.93	1.93	2582 (CL-V)
25.00	1.41	43299	0	0	45752	1.93	1.93	2688 (CL-V)
26.00	1.41	45076	0	0	47529	1.93	1.93	2794 (CL-V)
27.00	1.41	46852	0	0	49306	1.93	1.93	2900 (CL-V)
28.00	**1.41**	**48628**	**0**	**0**	**51082**	**1.92**	**1.92**	**3005 (3005-D)**
29.00	**1.41**	**50404**	**0**	**0**	**52857**	**1.92**	**1.92**	**3111 (3111-D)**
30.00	**1.41**	**52180**	**0**	**0**	**54633**	**1.92**	**1.92**	**3217 (3217-D)**
31.00	**1.42**	**53954**	**0**	**0**	**56408**	**1.92**	**1.92**	**3323 (3323-D)**
32.00	**1.42**	**55729**	**0**	**0**	**58182**	**1.92**	**1.92**	**3428 (3428-D)**
33.00	**1.42**	**57503**	**0**	**0**	**59957**	**1.92**	**1.92**	**3534 (3534-D)**

34.00	**1.42**	**59278**	**0**	**0**	**61731**	**1.92**	**1.92**	**3640 (3640-D)**
35.00	**1.42**	**61051**	**0**	**0**	**63505**	**1.92**	**1.92**	**3745 (3745-D)**

Selected Depth: 0 ft. (closest pipe depth: 0 ft)
(N/A) = SAMM analysis is not accurate at this depth use direct analysis for more accurate results.
(i.e. Bedding Types 2 or 3)
Fluid Load (2453 lbs/ft) included in the calculation of the Total Load

Pipe Analysis Report

Pipe Depth – The height of cover from the top of the pipe to the soil surface, m (ft).

Earth Load

Arching Factor – The ratio of the design soil load on the pipe to the load from the prism of soil immediately above the pipe (prism load). By multiplying the soil prism load by the Arching Factor, the Earth Load on the pipe will be determined. The Arching Factor is constant for Standard Installations in the positive projecting condition, but variable for all other bedding and installation conditions.

>Trans - (Applicable for Trench and Negative Projecting Conditions only) – When a trench or negative projecting design is performed, the soil load above the pipe may or may not be reduced by frictional forces between the insitu and placed soils, depending on the depth and width of the trench. A symbol of "Y" is shown when the trench width exceeds the width at which frictional forces reduce the soil load on the pipe (Yes, the transition width has been exceeded, and the positive projecting design governs). A symbol of "N" is shown if frictional forces reduce the load on the pipe (No, the transition width has not been exceeded).

Load – The load in kN/m (lbs/ft) imposed on the pipe from the soil.

Live Load – The load on the pipe resulting from a dynamic load at the surface, kN/m (lbs/ft).

Surcharge Load – The load in kN/m (lbs/ft) imposed on the pipe from surcharge loads such as buildings, stationary equipment, etc. on the soil surface above the pipe.

Total Load – The summation of all the loads on the pipe. This would include when applicable; Earth Load + Surcharge Load + Live Load + Fluid Load.

Note: Since the internal fluid load for a pipe is constant regardless of fill height it is not listed in the table. When the user chooses to consider fluid load, it is written below the table and included in the total load.

Bedding Factor

DL – The dead load bedding factor applied to the pipe at that depth. The higher the bedding factor, the greater the support that is given to the pipe by the surrounding soil. This factor is divided by the Total Load for the B, C, and D beddings only.

LL – The live load bedding factor applied to the pipe at that depth. The live load bedding factor accounts for concentrated loads resulting from live loads over pipe with shallow cover. For the Type 1, 2, 3, 4 and Jacking Installations the Live Load is divided by the lower of this value or the DL value, and all other loads are summed up and divided by the DL value.

Required D-Load 0.3mm (0.01 in) – The load the pipe is required to support in the three-edge bearing test with a crack equal to or less than 0.3 mm (0.01 in) which equates to the maximum stress induced on the pipe in the installed condition. The load is given in kN (lbs) per m (ft) length of pipe per mm (ft) of diameter (or span for noncircular pipe).

Required TEB-Load Ultimate – The load that the pipe is required to be able to support in the three-edge bearing test prior to failure. The load is given in kN (lbs) per m (ft) length of pipe.

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Three Edge Bearing Analysis - Results

Project Description

Project Title: WisDOT
Project Location: Madison,WI
Contract Number:
Country: US
Units: US Units
Alternative: p=0.3

Consultant: CNA Engineers
Contractor:
Analyzed By: CRE
Date: 11/14/2019
Comply To: ASTM (AASHTO)

D-LOAD REQUIREMENTS FOR A 106 (in) SPAN HORIZONTAL ELLIPTICAL PIPE

PIPE DATA

Span (in.)	106
Rise (in.)	68
Wall Thickness (in.)	8.500

INSTALLATION CONDITIONS

Minimum Depth of Fill (ft)	10.00
Maxmum Depth of Fill (ft)	35.00
Soil Density (lb/cu. ft)	120.0
Installation Type	Positive Projecting Embankment
Positive Projection Ratio	0.30
Soil Lateral Pressure Ratio	0.33
Soil Lateral Pressure/Friction Term (kμ)	0.165
Soil Lateral Fraction 'm'	0.30
Settlement Ratio	0.70

ADDITIONAL LOADS

No Live or Surcharge Loads

Fluid Load (lb/ft)	2453

FACTOR OF SAFETY

Factor of Safety on 0.01 Inch Crack D-Load (Earth, Live)	1.00 1.00
Factor of Safety on Ultimate Earth and Live Load (ASTM C 76)	
DL.01 Less Than or Equal To 2000 lbs/ft/ft	1.50
DL.01 Greater Than or Equal To 3000 lbs/ft/ft	1.25
DL.01 Between 2000 and 3000 lbs/ft/ft	Interpolated

D-LOAD REQUIREMENTS FOR 106 in. SPAN HORIZONTAL ELLIPTICAL PIPE
Results of Analysis for Bedding Type 2

Pipe Depth	Arching Factor	Earth Load (lb/ft)	Live Load (lb/ft)	Surch Load (lb/ft)	Total Load (lb/ft)	Bed Fact DL	Bed Fact LL	Required D-Load 0.01 in. (lb/ft/ft)
10.00	**1.18**	**14511**	**0**	**0**	**16964**	**2.15**	**2.15**	**891 (CL-II)**
11.00	1.20	16236	0	0	18689	2.15	2.15	982 (CL-II)
12.00	**1.22**	**18017**	**0**	**0**	**20470**	**2.15**	**2.15**	**1077 (CL-III)**
13.00	1.23	19650	0	0	22104	2.15	2.15	1163 (CL-III)
14.00	1.23	21211	0	0	23664	2.15	2.15	1245 (CL-III)
15.00	1.23	22773	0	0	25226	2.15	2.15	1327 (CL-III)
16.00	**1.24**	**24322**	**0**	**0**	**26775**	**2.15**	**2.15**	**1409 (CL-IV)**
17.00	1.24	25871	0	0	28324	2.15	2.15	1490 (CL-IV)
18.00	1.24	27419	0	0	29872	2.15	2.15	1572 (CL-IV)
19.00	1.24	28967	0	0	31420	2.15	2.15	1653 (CL-IV)
20.00	1.24	30514	0	0	32967	2.15	2.15	1735 (CL-IV)
21.00	1.24	32061	0	0	34514	2.15	2.15	1816 (CL-IV)
22.00	1.24	33607	0	0	36061	2.15	2.15	1898 (CL-IV)
23.00	1.24	35154	0	0	37607	2.15	2.15	1979 (CL-IV)
24.00	**1.24**	**36700**	**0**	**0**	**39153**	**2.15**	**2.15**	**2061 (CL-V)**
25.00	1.24	38246	0	0	40699	2.15	2.15	2142 (CL-V)
26.00	1.24	39792	0	0	42245	2.15	2.15	2224 (CL-V)
27.00	1.24	41338	0	0	43791	2.15	2.15	2305 (CL-V)
28.00	1.25	42884	0	0	45337	2.15	2.15	2386 (CL-V)
29.00	1.25	44429	0	0	46883	2.15	2.15	2468 (CL-V)
30.00	1.25	45975	0	0	48428	2.15	2.15	2549 (CL-V)
31.00	1.25	47521	0	0	49974	2.15	2.15	2631 (CL-V)
32.00	1.25	49066	0	0	51519	2.15	2.15	2712 (CL-V)
33.00	1.25	50612	0	0	53065	2.15	2.15	2794 (CL-V)
34.00	1.25	52157	0	0	54610	2.15	2.15	2875 (CL-V)
35.00	1.25	53702	0	0	56156	2.15	2.15	2956 (CL-V)

Selected Depth: 0 ft. (closest pipe depth: 0 ft)
(N/A) = SAMM analysis is not accurate at this depth use direct analysis for more accurate results.

(i.e. Bedding Types 2 or 3)
Fluid Load (2453 lbs/ft) included in the calculation of the Total Load

D-LOAD REQUIREMENTS FOR 106 in. SPAN HORIZONTAL ELLIPTICAL PIPE
Results of Analysis for Bedding Type 3

Pipe Depth	Arching Factor	Earth Load (lb/ft)	Live Load (lb/ft)	Surch Load (lb/ft)	Total Load (lb/ft)	Bed Fact DL	Bed Fact LL	Required D-Load 0.01 in. (lb/ft/ft)
10.00	**1.18**	**14511**	**0**	**0**	**16964**	**1.77**	**1.77**	**1083 (CL-III)**
11.00	1.20	16236	0	0	18689	1.77	1.77	1193 (CL-III)
12.00	1.22	18017	0	0	20470	1.77	1.77	1307 (CL-III)
13.00	**1.23**	**19650**	**0**	**0**	**22104**	**1.77**	**1.77**	**1412 (CL-IV)**
14.00	1.23	21211	0	0	23664	1.77	1.77	1511 (CL-IV)
15.00	1.23	22773	0	0	25226	1.77	1.77	1611 (CL-IV)
16.00	1.24	24322	0	0	26775	1.77	1.77	1710 (CL-IV)
17.00	1.24	25871	0	0	28324	1.77	1.77	1809 (CL-IV)
18.00	1.24	27419	0	0	29872	1.77	1.77	1908 (CL-IV)
19.00	**1.24**	**28967**	**0**	**0**	**31420**	**1.77**	**1.77**	**2007 (CL-V)**
20.00	1.24	30514	0	0	32967	1.77	1.77	2106 (CL-V)
21.00	1.24	32061	0	0	34514	1.77	1.77	2205 (CL-V)
22.00	1.24	33607	0	0	36061	1.77	1.77	2304 (CL-V)
23.00	1.24	35154	0	0	37607	1.77	1.77	2403 (CL-V)
24.00	1.24	36700	0	0	39153	1.77	1.77	2502 (CL-V)
25.00	1.24	38246	0	0	40699	1.77	1.77	2601 (CL-V)
26.00	1.24	39792	0	0	42245	1.77	1.77	2699 (CL-V)
27.00	1.24	41338	0	0	43791	1.77	1.77	2798 (CL-V)
28.00	1.25	42884	0	0	45337	1.77	1.77	2897 (CL-V)
29.00	1.25	44429	0	0	46883	1.77	1.77	2996 (CL-V)
30.00	**1.25**	**45975**	**0**	**0**	**48428**	**1.77**	**1.77**	**3095 (3095-D)**
31.00	**1.25**	**47521**	**0**	**0**	**49974**	**1.77**	**1.77**	**3193 (3193-D)**
32.00	**1.25**	**49066**	**0**	**0**	**51519**	**1.77**	**1.77**	**3292 (3292-D)**
33.00	**1.25**	**50612**	**0**	**0**	**53065**	**1.77**	**1.77**	**3391 (3391-D)**
34.00	**1.25**	**52157**	**0**	**0**	**54610**	**1.77**	**1.77**	**3490 (3490-D)**

35.00	**1.25**	**53702**	**0**	**0**	**56156**	**1.77**	**1.77**	**3589 (3589-D)**

Selected Depth: 0 ft. (closest pipe depth: 0 ft)
(N/A) = SAMM analysis is not accurate at this depth use direct analysis for more accurate results.
(i.e. Bedding Types 2 or 3)
Fluid Load (2453 lbs/ft) included in the calculation of the Total Load

Pipe Analysis Report

Pipe Depth – The height of cover from the top of the pipe to the soil surface, m (ft).

Earth Load

Arching Factor – The ratio of the design soil load on the pipe to the load from the prism of soil immediately above the pipe (prism load). By multiplying the soil prism load by the Arching Factor, the Earth Load on the pipe will be determined. The Arching Factor is constant for Standard Installations in the positive projecting condition, but variable for all other bedding and installation conditions.

>Trans - (Applicable for Trench and Negative Projecting Conditions only) – When a trench or negative projecting design is performed, the soil load above the pipe may or may not be reduced by frictional forces between the insitu and placed soils, depending on the depth and width of the trench. A symbol of "Y" is shown when the trench width exceeds the width at which frictional forces reduce the soil load on the pipe (Yes, the transition width has been exceeded, and the positive projecting design governs). A symbol of "N" is shown if frictional forces reduce the load on the pipe (No, the transition width has not been exceeded).

Load – The load in kN/m (lbs/ft) imposed on the pipe from the soil.

Live Load – The load on the pipe resulting from a dynamic load at the surface, kN/m (lbs/ft).

Surcharge Load – The load in kN/m (lbs/ft) imposed on the pipe from surcharge loads such as buildings, stationary equipment, etc. on the soil surface above the pipe.

Total Load – The summation of all the loads on the pipe. This would include when applicable; Earth Load + Surcharge Load + Live Load + Fluid Load.

Note: Since the internal fluid load for a pipe is constant regardless of fill height it is not listed in the table. When the user chooses to consider fluid load, it is written below the table and included in the total load.

Bedding Factor

DL – The dead load bedding factor applied to the pipe at that depth. The higher the bedding factor, the greater the support that is given to the pipe by the surrounding soil. This factor is divided by the Total Load for the B, C, and D beddings only.

LL – The live load bedding factor applied to the pipe at that depth. The live load bedding factor accounts for concentrated loads resulting from live loads over pipe with shallow cover. For the Type 1, 2, 3, 4 and Jacking Installations the Live Load is divided by the lower of this value or the DL value, and all other loads are summed up and divided by the DL value.

Required D-Load 0.3mm (0.01 in) – The load the pipe is required to support in the three-edge bearing test with a crack equal to or less than 0.3 mm (0.01 in) which equates to the maximum stress induced on the pipe in the installed condition. The load is given in kN (lbs) per m (ft) length of pipe per mm (ft) of diameter (or span for noncircular pipe).

Required TEB-Load Ultimate – The load that the pipe is required to be able to support in the three-edge bearing test prior to failure. The load is given in kN (lbs) per m (ft) length of pipe.

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The successful application and use of this software product is dependent on the application of skilled engineering judgement supplied by the user and/or their consultant. The user of this software must select input values suitable to describe their specific engineering situation. The information presented in the computer output is for review, interpretation application, and approval by a qualified engineer who must assume full responsibility for verifying that all output is appropriate and correct.

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Attachment F:

AASHTO Indirect Design Calculations

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Indirect Design for RCP

AASHTO LRFD Section 12.10, 8th Edition

Client: Fisher, Bren and Sheridan
Project #: WisDOT 19-01
Calc'd by: CRE
Chk'd by: BKN
Date: 11/18/2019

References:

1. State of Wisconsin, Department of Transportation, Proposal #4, "Plan of Proposed Improvement", 5992-09-03, WISC 2017402, City of Madison, Dated August 2017
2. Reference Sections from AASHTO LRFD, 8th Edition

Description:

Determination of the Three-Edge Bearing Strength D-Load for Reinfoced Concrete Pipe by the Indirect Design Method.

Givens:

$R_i := 68\ in$ Internal rise of pipe

$S_i := 106\ in$ Internal span of pipe

$t := 8.5\ in$ Wall thickness of pipe

$B_c := S_i + 2 \cdot t = 10.25\ ft$ Out-to-out horizontal dimesion of pipe

$A_E := \pi \cdot \frac{R_i}{2} \cdot \frac{S_i}{2} = 39.314\ ft^2$ Area of pipe

$H := \begin{bmatrix} 15.1 \\ 24.3 \\ 30.2 \end{bmatrix} ft$ Class III, Class IV, Class Special — Max Depth of pipe burial

$\gamma_w := 62.4\ pcf$ Unit Weight of Water

$\gamma_s := 120\ pcf$ Unit Weight of Soil

Created with PTC Mathcad Express. See www.mathcad.com for more information.

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Project #: WisDOT 19-01
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Assumptions:

Table 12.10.2.1-1—Standard Embankment Installation Soils and Minimum Compaction Requirements

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	For soil foundation, use B_c/2.0 ft minimum, not less than 3.0 in. For rock foundation, use B_c ft minimum, not less than 6.0 in.	95% SW	90% SW, 95% ML, or 100% CL
Type 2—Installations are available for horizontal elliptical, vertical elliptical, and arch pipe	For soil foundation, use B_c/2.0 ft minimum, not less than 3.0 in. For rock foundation, use B_c ft minimum, not less than 6.0 in.	90% SW or 95% ML	85% SW, 90% ML, or 95% CL
Type 3—Installations are available for horizontal elliptical, vertical elliptical, and arch pipe	For soil foundation, use B_c/2.0 ft minimum, not less than 3.0 in. For rock foundation, use B_c ft minimum, not less than 6.0 in.	85% SW, 90% ML, or 95% CL	85% SW, 90% ML, or 95% CL
Type 4	For soil foundation, no bedding required. For rock foundation, use B_c/2.0 ft minimum, not less than 6.0 in.	No compaction required, except if CL, use 85% CL	No compaction required, except if CL, use 85% CL

Installation Type: 2

Table 12.10.4.3.2b-1—Design Values of Parameters in Bedding Factor Equation

Pipe Shape	C_A	Installation Type	C_N	Projection Ratio, p	x
Horizontal Elliptical and Arch	1.337	2	0.630	0.9	0.421
				0.7	0.369
		3	0.763	0.5	0.268
				0.3	0.148
Vertical Elliptical	1.021	2	0.516	0.9	0.718
				0.7	0.639
		3	0.615	0.5	0.457
				0.3	0.238

$p := 0.9$ projection ration, ratio of the vertical distance beween the outside top of the pipe and the ground of bedding surface to the outside vertical height of pipe — 12.10.4.3.2b

Specified Design Parameters:

$F_e := 1.4$ Soil-Structure Interaction factor for the specified installation — 12.10.2.1

$C_A := 1.337$ Constant corresponding to the shape of the pipe — 12.10.4.3.2b

$C_N := 0.630$ Parameter that is a function of the distribution of the vertical load and vertical reaction — 12.10.4.3.2b

$x := 0.421$ Parameter that is a function of the vertical project of the pipe over which lateral pressure is effective — 12.10.4.3.2b

$B_{FLL} := 2.2$ Live Load Bedding Factor — 12.10.4.3.2c

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Calculated Design Parameters:

$$q := 0.23\left(\frac{p}{F_e}\right)\left(1+0.35\cdot p\cdot\frac{B_c}{H}\right)=\begin{bmatrix}0.179\\0.168\\0.164\end{bmatrix}$$

Ratio of the total lateral pressure to the total vertical fill load — Eq. 12.10.4.3.2b-2

$$B_{FE} := \frac{C_A}{C_N - x\cdot q}=\begin{bmatrix}2.41\\2.39\\2.38\end{bmatrix}$$

Earth Load Bedding Factor — Eq. 12..10.4.3.2b-1

Total Unfactored Earth Load:

$$W_E := F_e\cdot\gamma_s\cdot B_c\cdot H=\begin{bmatrix}26\\41.84\\52\end{bmatrix}\ \frac{kip}{ft}$$

Total unfactored earth load — Eq. 12.10.2.1-1

Total Unfactored Fluid Load in Pipe:

$$W_F := A_E\cdot\gamma_w = 2.453\ \frac{kip}{ft}$$

Total unfactored fluid load in the pipe

Total Unfactored Live Load on unit length of pipe:

According to AASHTO Article 3.6.1.2.6, Distribution of wheel load throught earth fills, for single-span culvert, the effects of live load may be neglected where the depth of fill is more than 8ft and exceeds the span length.

$$W_L := 0\ \frac{kip}{ft}$$

Total unfactored live load on unit length of pipe

Three-Edge Bearing Resistance D-Load

$$D := \left(\frac{1}{S_i}\right)\left(\frac{W_E+W_F}{B_{FE}}+\frac{W_L}{B_{FLL}}\right)=\begin{bmatrix}1336\\2099\\2587\end{bmatrix}\ psf$$

D-Load — Eq. 12.10.4.3.1-1

$D_{III} := D(0) = 1336\ psf$ D-Load for Class III Pipe

$D_{IV} := D(1) = 2099\ psf$ D-Load for Class IV Pipe

$D_{Special} := D(2) = 2587\ psf$ D-Load for Class Special Pipe

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2. Reference Sections from AASHTO LRFD, 8th Edition

Description:

Determination of the Three-Edge Bearing Strength D-Load for Reinfoced Concrete Pipe by the Indirect Design Method.

Givens:

$R_i := 68\ in$ Internal rise of pipe

$S_i := 106\ in$ Internal span of pipe

$t := 8.5\ in$ Wall thickness of pipe

$B_c := S_i + 2 \cdot t = 10.25\ ft$ Out-to-out horizontal dimesion of pipe

$A_E := \pi \cdot \frac{R_i}{2} \cdot \frac{S_i}{2} = 39.314\ ft^2$ Area of pipe

$H := \begin{bmatrix} 15.1 \\ 24.3 \\ 30.2 \end{bmatrix} ft$ Class III, Class IV, Class Special — Max Depth of pipe burial

$\gamma_w := 62.4\ pcf$ Unit Weight of Water

$\gamma_s := 120\ pcf$ Unit Weight of Soil

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AASHTO LRFD Section 12.10, 8th Edition

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Assumptions:

Table 12.10.2.1-1—Standard Embankment Installation Soils and Minimum Compaction Requirements

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	For soil foundation, use B_c/2.0 ft minimum, not less than 3.0 in. For rock foundation, use B_c ft minimum, not less than 6.0 in.	95% SW	90% SW, 95% ML, or 100% CL
Type 2—Installations are available for horizontal elliptical, vertical elliptical, and arch pipe	For soil foundation, use B_c/2.0 ft minimum, not less than 3.0 in. For rock foundation, use B_c ft minimum, not less than 6.0 in.	90% SW or 95% ML	85% SW, 90% ML, or 95% CL
Type 3—Installations are available for horizontal elliptical, vertical elliptical, and arch pipe	For soil foundation, use B_c/2.0 ft minimum, not less than 3.0 in. For rock foundation, use B_c ft minimum, not less than 6.0 in.	85% SW, 90% ML, or 95% CL	85% SW, 90% ML, or 95% CL
Type 4	For soil foundation, no bedding required. For rock foundation, use B_c/2.0 ft minimum, not less than 6.0 in.	No compaction required, except if CL, use 85% CL	No compaction required, except if CL, use 85% CL

Installation Type: 2

Table 12.10.4.3.2b-1—Design Values of Parameters in Bedding Factor Equation

Pipe Shape	C_A	Installation Type	C_N	Projection Ratio, p	x
Horizontal Elliptical and Arch	1.337	2	0.630	0.9	0.421
				0.7	0.369
		3	0.763	0.5	0.268
				0.3	0.148
Vertical Elliptical	1.021	2	0.516	0.9	0.718
				0.7	0.639
		3	0.615	0.5	0.457
				0.3	0.238

$p := 0.7$ projection ration, ratio of the vertical distance beween the outside top of the pipe and the ground of bedding surface to the outside vertical height of pipe — 12.10.4.3.2b

Specified Design Parameters:

$F_e := 1.4$ Soil-Structure Interaction factor for the specified installation — 12.10.2.1

$C_A := 1.337$ Constant corresponding to the shape of the pipe — 12.10.4.3.2b

$C_N := 0.630$ Parameter that is a function of the distribution of the vertical load and vertical reaction — 12.10.4.3.2b

$x := 0.369$ Parameter that is a function of the vertical project of the pipe over which lateral pressure is effective — 12.10.4.3.2b

$B_{FLL} := 2.2$ Live Load Bedding Factor — 12.10.4.3.2c

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Calculated Design Parameters:

$$q := 0.23\left(\frac{p}{F_e}\right)\left(1+0.35\cdot p\cdot\frac{B_c}{H}\right)=\begin{bmatrix}0.134\\0.127\\0.125\end{bmatrix}$$

Ratio of the total lateral pressure to the total vertical fill load — Eq. 12.10.4.3.2b-2

$$B_{FE} := \frac{C_A}{C_N - x\cdot q}=\begin{bmatrix}2.3\\2.29\\2.29\end{bmatrix}$$

Earth Load Bedding Factor — Eq. 12..10.4.3.2b-1

Total Unfactored Earth Load:

$$W_E := F_e\cdot\gamma_s\cdot B_c\cdot H=\begin{bmatrix}26\\41.84\\52\end{bmatrix}\ \frac{kip}{ft}$$

Total unfactored earth load — Eq. 12.10.2.1-1

Total Unfactored Fluid Load in Pipe:

$$W_F := A_E\cdot\gamma_w = 2.453\ \frac{kip}{ft}$$

Total unfactored fluid load in the pipe

Total Unfactored Live Load on unit length of pipe:

According to AASHTO Article 3.6.1.2.6, Distribution of wheel load throught earth fills, for single-span culvert, the effects of live load may be neglected where the depth of fill is more than 8ft and exceeds the span length.

$$W_L := 0\ \frac{kip}{ft}$$

Total unfactored live load on unit length of pipe

Three-Edge Bearing Resistance D-Load

$$D := \left(\frac{1}{S_i}\right)\left(\frac{W_E+W_F}{B_{FE}}+\frac{W_L}{B_{FLL}}\right)=\begin{bmatrix}1399\\2187\\2693\end{bmatrix}\ psf$$

D-Load — Eq. 12.10.4.3.1-1

$D_{III} := D(0) = 1399\ psf$ D-Load for Class III Pipe

$D_{IV} := D(1) = 2187\ psf$ D-Load for Class IV Pipe

$D_{Special} := D(2) = 2693\ psf$ D-Load for Class Special Pipe

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Indirect Design for RCP

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2. Reference Sections from AASHTO LRFD, 8th Edition

Description:

Determination of the Three-Edge Bearing Strength D-Load for Reinfoced Concrete Pipe by the Indirect Design Method.

Givens:

$R_i := 68\ in$ Internal rise of pipe

$S_i := 106\ in$ Internal span of pipe

$t := 8.5\ in$ Wall thickness of pipe

$B_c := S_i + 2 \cdot t = 10.25\ ft$ Out-to-out horizontal dimesion of pipe

$A_E := \pi \cdot \frac{R_i}{2} \cdot \frac{S_i}{2} = 39.314\ ft^2$ Area of pipe

$H := \begin{bmatrix} 15.1 \\ 24.3 \\ 30.2 \end{bmatrix} ft$ Class III, Class IV, Class Special — Max Depth of pipe burial

$\gamma_w := 62.4\ pcf$ Unit Weight of Water

$\gamma_s := 120\ pcf$ Unit Weight of Soil

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Assumptions:

Table 12.10.2.1-1—Standard Embankment Installation Soils and Minimum Compaction Requirements

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
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Type 3—Installations are available for horizontal elliptical, vertical elliptical, and arch pipe	For soil foundation, use B_c/2.0 ft minimum, not less than 3.0 in. For rock foundation, use B_c ft minimum, not less than 6.0 in.	85% SW, 90% ML, or 95% CL	85% SW, 90% ML, or 95% CL
Type 4	For soil foundation, no bedding required. For rock foundation, use B_c/2.0 ft minimum, not less than 6.0 in.	No compaction required, except if CL, use 85% CL	No compaction required, except if CL, use 85% CL

Installation Type: 3

Table 12.10.4.3.2b-1—Design Values of Parameters in Bedding Factor Equation

Pipe Shape	C_A	Installation Type	C_N	Projection Ratio, p	x
Horizontal Elliptical and Arch	1.337	2	0.630	0.9	0.421
				0.7	0.369
		3	0.763	0.5	0.268
				0.3	0.148
Vertical Elliptical	1.021	2	0.516	0.9	0.718
				0.7	0.639
		3	0.615	0.5	0.457
				0.3	0.238

$p := 0.5$ projection ration, ratio of the vertical distance beween the outside top of the pipe and the ground of bedding surface to the outside vertical height of pipe — 12.10.4.3.2b

Specified Design Parameters:

$F_e := 1.4$ Soil-Structure Interaction factor for the specified installation — 12.10.2.1

$C_A := 1.337$ Constant corresponding to the shape of the pipe — 12.10.4.3.2b

$C_N := 0.763$ Parameter that is a function of the distribution of the vertical load and vertical reaction — 12.10.4.3.2b

$x := 0.268$ Parameter that is a function of the vertical project of the pipe over which lateral pressure is effective — 12.10.4.3.2b

$B_{FLL} := 2.2$ Live Load Bedding Factor — 12.10.4.3.2c

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Calculated Design Parameters:

$$q := 0.23\left(\frac{p}{F_e}\right)\left(1+0.35\cdot p\cdot\frac{B_c}{H}\right)=\begin{bmatrix}0.092\\0.088\\0.087\end{bmatrix}$$

Ratio of the total lateral pressure to the total vertical fill load — Eq. 12.10.4.3.2b-2

$$B_{FE} := \frac{C_A}{C_N - x\cdot q}=\begin{bmatrix}1.81\\1.81\\1.81\end{bmatrix}$$

Earth Load Bedding Factor — Eq. 12..10.4.3.2b-1

Total Unfactored Earth Load:

$$W_E := F_e\cdot\gamma_s\cdot B_c\cdot H=\begin{bmatrix}26\\41.84\\52\end{bmatrix}\ \frac{kip}{ft}$$

Total unfactored earth load — Eq. 12.10.2.1-1

Total Unfactored Fluid Load in Pipe:

$$W_F := A_E\cdot\gamma_w = 2.453\ \frac{kip}{ft}$$

Total unfactored fluid load in the pipe

Total Unfactored Live Load on unit length of pipe:

According to AASHTO Article 3.6.1.2.6, Distribution of wheel load throught earth fills, for single-span culvert, the effects of live load may be neglected where the depth of fill is more than 8ft and exceeds the span length.

$$W_L := 0\ \frac{kip}{ft}$$

Total unfactored live load on unit length of pipe

Three-Edge Bearing Resistance D-Load

$$D := \left(\frac{1}{S_i}\right)\left(\frac{W_E+W_F}{B_{FE}}+\frac{W_L}{B_{FLL}}\right)=\begin{bmatrix}1779\\2773\\3411\end{bmatrix}\ psf$$

D-Load — Eq. 12.10.4.3.1-1

$D_{III} := D(0) = 1779\ psf$ D-Load for Class III Pipe

$D_{IV} := D(1) = 2773\ psf$ D-Load for Class IV Pipe

$D_{Special} := D(2) = 3411\ psf$ D-Load for Class Special Pipe

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2. Reference Sections from AASHTO LRFD, 8th Edition

Description:

Determination of the Three-Edge Bearing Strength D-Load for Reinfoced Concrete Pipe by the Indirect Design Method.

Givens:

$R_i := 68\ in$ Internal rise of pipe

$S_i := 106\ in$ Internal span of pipe

$t := 8.5\ in$ Wall thickness of pipe

$B_c := S_i + 2 \cdot t = 10.25\ ft$ Out-to-out horizontal dimesion of pipe

$A_E := \pi \cdot \frac{R_i}{2} \cdot \frac{S_i}{2} = 39.314\ ft^2$ Area of pipe

$H := \begin{bmatrix} 15.1 \\ 24.3 \\ 30.2 \end{bmatrix} ft$ Class III, Class IV, Class Special — Max Depth of pipe burial

$\gamma_w := 62.4\ pcf$ Unit Weight of Water

$\gamma_s := 120\ pcf$ Unit Weight of Soil

Created with PTC Mathcad Express. See www.mathcad.com for more information.

CONSULTING ENGINEERS

Indirect Design for RCP

AASHTO LRFD Section 12.10, 8th Edition

Client: Fisher, Bren and Sheridan
Project #: WisDOT 19-01
Calc'd by: CRE
Chk'd by: BKN
Date: 11/18/2019

Assumptions:

Table 12.10.2.1-1—Standard Embankment Installation Soils and Minimum Compaction Requirements

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	For soil foundation, use B_c/2.0 ft minimum, not less than 3.0 in. For rock foundation, use B_c ft minimum, not less than 6.0 in.	95% SW	90% SW, 95% ML, or 100% CL
Type 2—Installations are available for horizontal elliptical, vertical elliptical, and arch pipe	For soil foundation, use B_c/2.0 ft minimum, not less than 3.0 in. For rock foundation, use B_c ft minimum, not less than 6.0 in.	90% SW or 95% ML	85% SW, 90% ML, or 95% CL
Type 3—Installations are available for horizontal elliptical, vertical elliptical, and arch pipe	For soil foundation, use B_c/2.0 ft minimum, not less than 3.0 in. For rock foundation, use B_c ft minimum, not less than 6.0 in.	85% SW, 90% ML, or 95% CL	85% SW, 90% ML, or 95% CL
Type 4	For soil foundation, no bedding required. For rock foundation, use B_c/2.0 ft minimum, not less than 6.0 in.	No compaction required, except if CL, use 85% CL	No compaction required, except if CL, use 85% CL

Installation Type: 3

Table 12.10.4.3.2b-1—Design Values of Parameters in Bedding Factor Equation

Pipe Shape	C_A	Installation Type	C_N	Projection Ratio, p	x
Horizontal Elliptical and Arch	1.337	2	0.630	0.9	0.421
				0.7	0.369
		3	0.763	0.5	0.268
				0.3	0.148
Vertical Elliptical	1.021	2	0.516	0.9	0.718
				0.7	0.639
		3	0.615	0.5	0.457
				0.3	0.238

$p := 0.3$ projection ration, ratio of the vertical distance beween the outside top of the pipe and the ground of bedding surface to the outside vertical height of pipe — 12.10.4.3.2b

Specified Design Parameters:

$F_e := 1.4$ Soil-Structure Interaction factor for the specified installation — 12.10.2.1

$C_A := 1.337$ Constant corresponding to the shape of the pipe — 12.10.4.3.2b

$C_N := 0.763$ Parameter that is a function of the distribution of the vertical load and vertical reaction — 12.10.4.3.2b

$x := 0.148$ Parameter that is a function of the vertical project of the pipe over which lateral pressure is effective — 12.10.4.3.2b

$B_{FLL} := 2.2$ Live Load Bedding Factor — 12.10.4.3.2c

Created with PTC Mathcad Express. See www.mathcad.com for more information.

CONSULTING ENGINEERS

Indirect Design for RCP

AASHTO LRFD Section 12.10, 8th Edition

Client: Fisher, Bren and Sheridan
Project #: WisDOT 19-01
Calc'd by: CRE
Chk'd by: BKN
Date: 11/18/2019

Calculated Design Parameters:

$$q := 0.23\left(\frac{p}{F_e}\right)\left(1+0.35\cdot p\cdot\frac{B_c}{H}\right)=\begin{bmatrix}0.053\\0.051\\0.051\end{bmatrix}$$

Ratio of the total lateral pressure to the total vertical fill load — Eq. 12.10.4.3.2b-2

$$B_{FE} := \frac{C_A}{C_N - x\cdot q}=\begin{bmatrix}1.77\\1.77\\1.77\end{bmatrix}$$

Earth Load Bedding Factor — Eq. 12..10.4.3.2b-1

Total Unfactored Earth Load:

$$W_E := F_e\cdot\gamma_s\cdot B_c\cdot H=\begin{bmatrix}26\\41.84\\52\end{bmatrix}\ \frac{kip}{ft}$$

Total unfactored earth load — Eq. 12.10.2.1-1

Total Unfactored Fluid Load in Pipe:

$$W_F := A_E\cdot\gamma_w = 2.453\ \frac{kip}{ft}$$

Total unfactored fluid load in the pipe

Total Unfactored Live Load on unit length of pipe:

According to AASHTO Article 3.6.1.2.6, Distribution of wheel load throught earth fills, for single-span culvert, the effects of live load may be neglected where the depth of fill is more than 8ft and exceeds the span length.

$$W_L := 0\ \frac{kip}{ft}$$

Total unfactored live load on unit length of pipe

Three-Edge Bearing Resistance D-Load

$$D := \left(\frac{1}{S_i}\right)\left(\frac{W_E+W_F}{B_{FE}}+\frac{W_L}{B_{FLL}}\right)=\begin{bmatrix}1820\\2833\\3483\end{bmatrix}\ psf$$

D-Load — Eq. 12.10.4.3.1-1

$D_{III} := D(0) = 1820\ psf$ D-Load for Class III Pipe

$D_{IV} := D(1) = 2833\ psf$ D-Load for Class IV Pipe

$D_{Special} := D(2) = 3483\ psf$ D-Load for Class Special Pipe

Created with PTC Mathcad Express. See www.mathcad.com for more information.

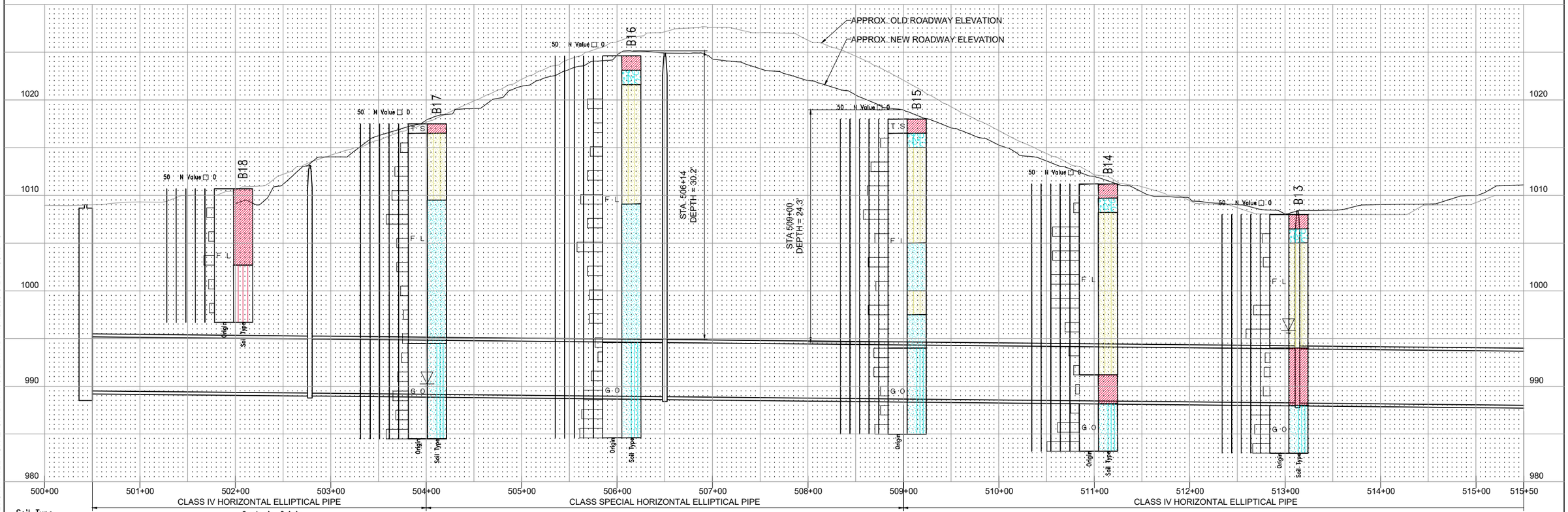
Attachment G:

Raymond Road Sewer – Boring and Pipe Classes Drawings



0 50' 100'
HORIZONTAL SCALE

0 5' 10'
VERTICAL SCALE



Soil Type

- SM
- ML
- CL
- GM
- SC
- SP-SM
- SP
- GP

Geologic Origin

- F L FILL ORIGIN
- G O GLACIAL OUTWASH
- T S TOPSOIL

▽ GROUNDWATER LEVEL IN BORING

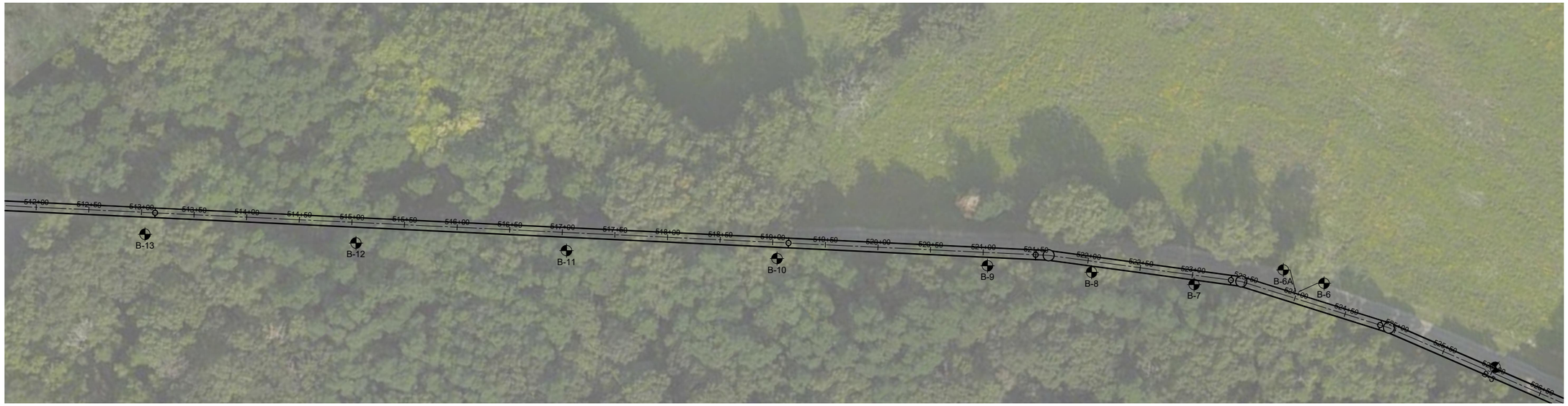
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MINNEAPOLIS, MN

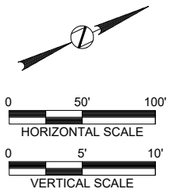
RAYMOND RD SEWER - BORINGS AND PIPE CLASSES

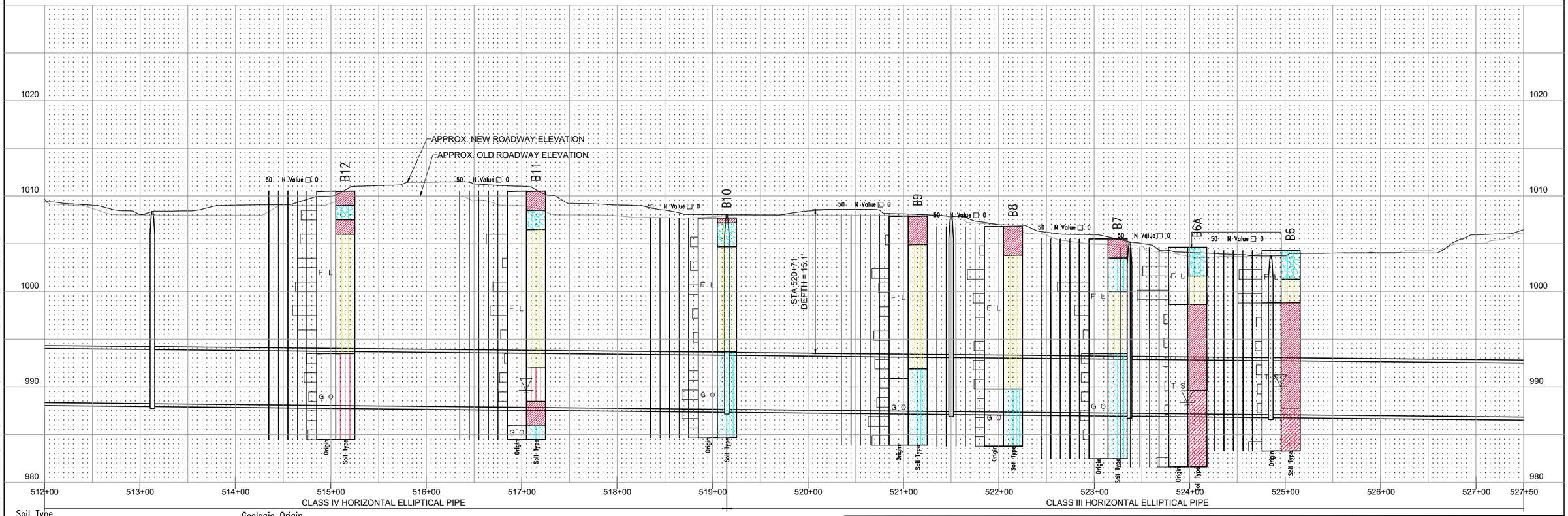
PLAN & PROFILE - STA 500+00 TO 515+50

DESIGNED BKN	DATE 11/22/2019
DRAWN CRE	PROJECT 5992-09-83
	DRAWING **1 OF 3**

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Soil Type

SM	SC
ML	SP-SM
CL	SP
GM	GP

Geologic Origin

F L	FILL ORIGIN
G O	GLACIAL OUTWASH
T S	TOPSOIL

▽ GROUNDWATER LEVEL IN BORING

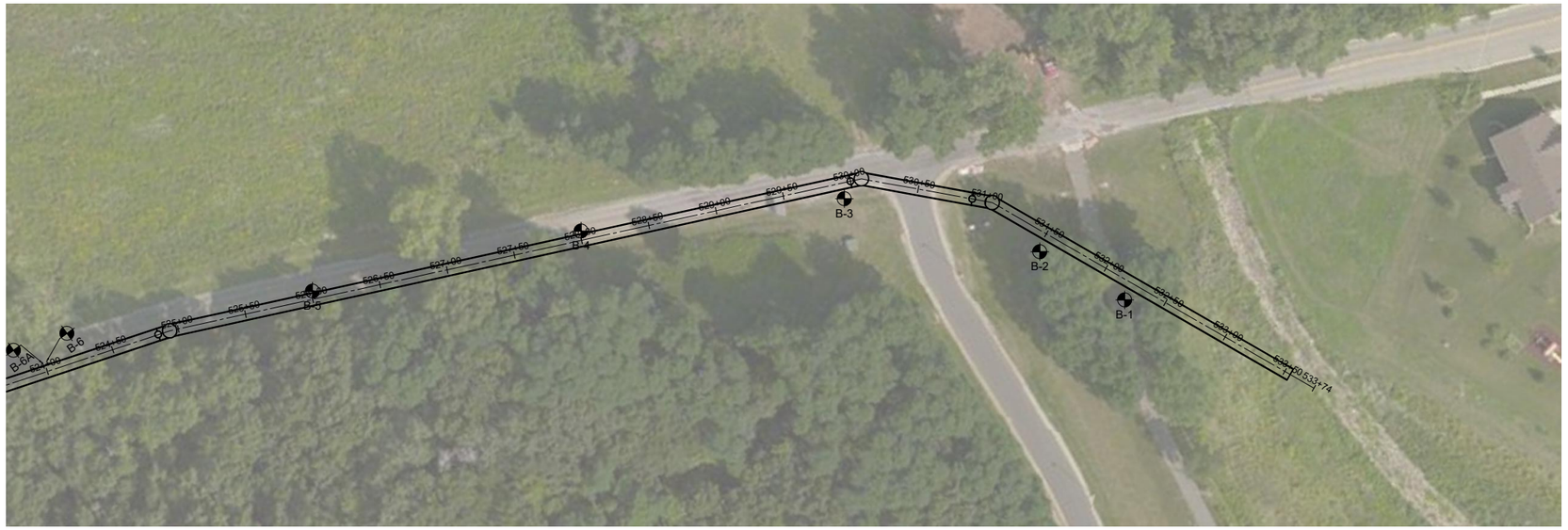
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RAYMOND RD SEWER - BORINGS AND PIPE CLASSES

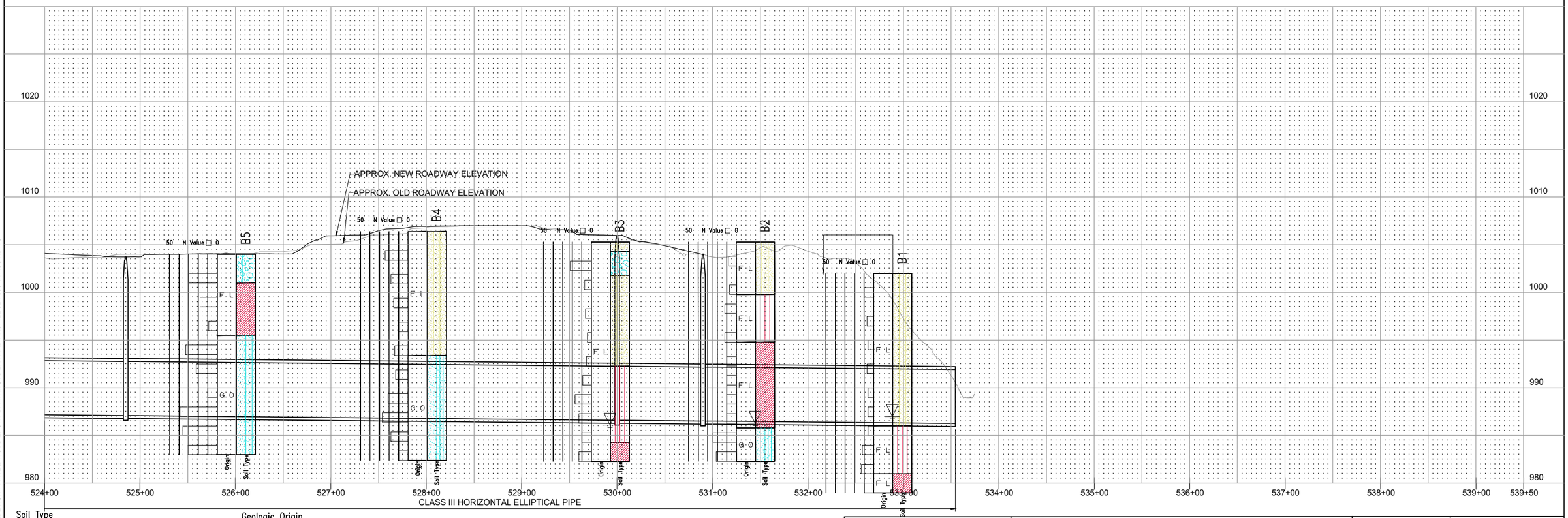
PLAN & PROFILE - STA 512+00 TO 527+50

DESIGNED: BKN	DATE: 11/22/2019
DRAWN: CRE	PROJECT: 5992-09-83
	DRAWING: **2 OF 3**

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Soil Type

- SM
- ML
- CL
- GM
- SC
- SP-SM
- SP
- GP

Geologic Origin

- F L FILL ORIGIN
- G O GLACIAL OUTWASH
- T S TOPSOIL

GROUNDWATER LEVEL IN BORING

CNA CONSULTING ENGINEERS
MINNEAPOLIS, MN

RAYMOND RD SEWER - BORINGS AND PIPE CLASSES

PLAN & PROFILE - STA 524+00 TO 539+50

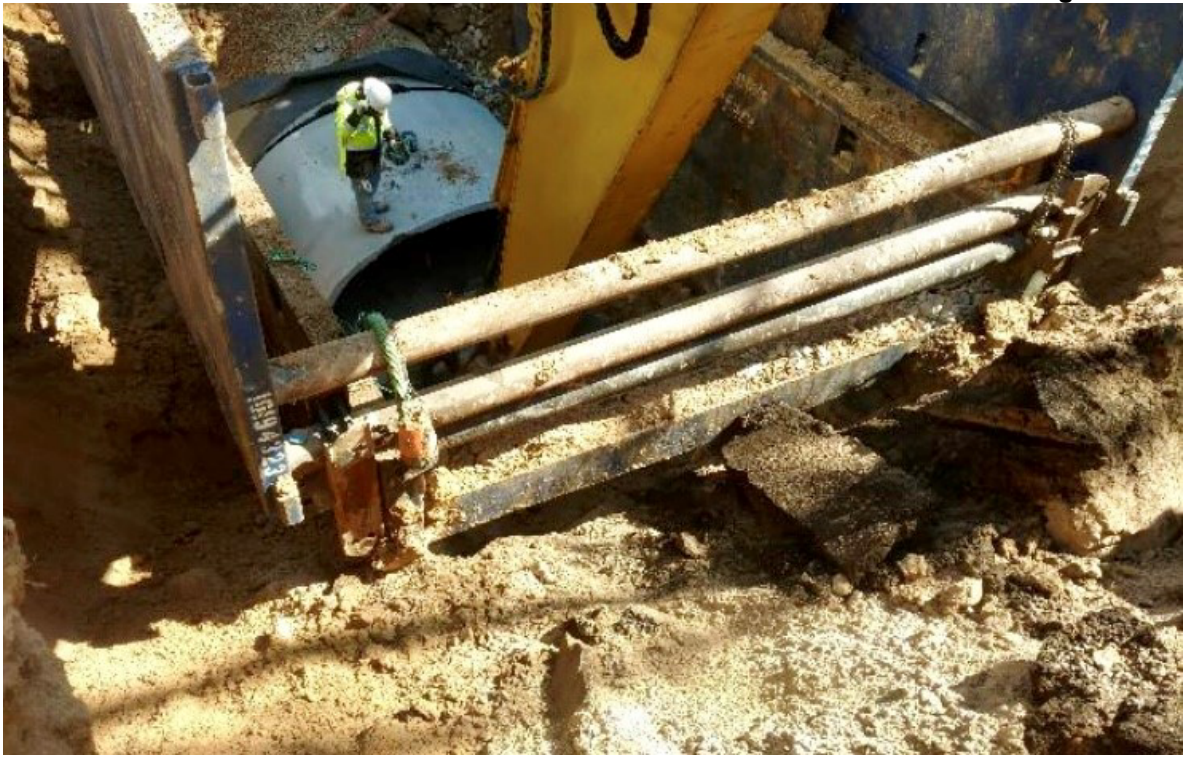
DESIGNED: BKN	DATE: 11/22/2019
DRAWN: CRE	PROJECT: 5992-09-83
	DRAWING: **3 OF 3**

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Attachment H:

Pipe Installation Photos







January 13, 2020

Mr. Dan Weinkauf
Integrity Grading and Excavating, Inc.
605 Grossman Drive
Schofield, WI 54476

VIA E-Mail: dan@integrityge.com

RE: Raymond Road, Verona, Wisconsin – Culvert Pipe Restoration Proposal (Final Revision)

Dear Mr. Weinkauf:

Engineering & Construction Innovations (ECI) is pleased to submit this final revised proposal for the Raymond Road Culvert Pipe Restoration. We have based our proposal on information exchanged over the course of the last month and the plans and specifications developed by BDA Associates.

Scope of Work

ECI has developed our scope of work based on the following major activities:

Mobilization:

- Equipment and material
- Cofferdam and dewater discharge end of pipe
- Bypass internal flow
- Frost projection and heat
- Power and lighting
- Material storage, transport and protection
- Water usage
- Clean pipe (Once)
- Access to work

We will mobilize to the project site and set up to utilize the existing culvert apron as the major construction access to the work areas inside of the existing concrete pipe. The mouth of the existing culvert will be developed by adding some additional clean course aggregate fill to create a ramp down into the small basin and into the apron of the pipe. Crews will install and secure temporary utilities inside the pipe consisting of temporary electric power cords, Duraplus ABS compressed airline, PVC potable water line and a 6-inch PVC bypass pipe. All temporary utilities will be removed upon completion of the work.

Water control will be paramount during the work to maintain grouting quality and the project schedule. ECI plans on constructing a partial cofferdam/overflow weir in the invert of the upstream manhole to catch water inflows with electric submersible pump(s) connected to a 6-inch PVC bypass pipe to convey flows through the entire length of the project. A low-flow weir bypass pipe will be constructed in the CMU weir and an inflatable sewer ball will provide positive sealing when bypassing water. The sewer ball will be deflated and removed for any pump maintenance or if significant precipitation is to occur and more pipe capacity is needed. ECI has successfully used this system before on storm tunnel rehabilitation projects to handle dry weather and moderate wet weather flows. ECI will monitor weather forecasts and plan the work sequences accordingly should significant wet weather events occur during construction. All equipment and personnel will be evacuated from the tunnel and temporary utilities removed or secured should an event be eminent. We have included a preliminary drawing of the temporary upstream CMU bypass weir and a general arrangement of the utilities to be installed within the pipe to facilitate the repair work. Photos from past projects using similar stormwater bypass systems are also attached for further reference. All temporary measures will be completely removed upon completion of the work and any anchor holes patched with an approved mortar.

Temporary heating is planned for the work during the periods where the ambient underground temperature of the concrete pipe surface is less than 45 degrees. Heating will involve 1-3 surface mounted indirect-fired forced air units feeding ventilation trunk lines inserted into the upstream and intermediate manhole structures to achieve proper working conditions. Air bulkheads will be installed as needed at the outlet portal of the pipe as well as any intermediate manholes/pipes that contribute to heat loss underground to further regulate temperature and promote proper ventilation of the workspace in accordance with applicable OSHA standards for confined spaces.

ECI will be constructing temporary shelter(s) to properly receive and store the various grouts and specialty construction components necessary to complete the work. These temporary provisions will likely require heating to maintain products within the limits set by the manufacturers and the project specifications. We have significant experience working with all of the grouts required for the project and proper cold weather handling for quality results.

We anticipate maintaining a full-time top land crew consisting of a minimum of two personnel dedicated to receiving truck shipments and efficiently storing materials into the site erected shelters. In addition, this crew will be in constant communication with underground personnel via a radio repeater connected to an underground leaky wire system and supply any needed tools or materials below ground using existing manhole structures. This radio system allows the underground workers direct communication with the top-side team members to maintain productivity and safety throughout the project. The personnel above ground will be responsible for monitoring weather forecasts and current conditions working in conjunction with the project superintendent.

Potable water for the project will be obtained from an existing fire hydrant within the project area. ECI will request a meter from the local water authority and pay all water usage fees.

Scope:

Remedial grouting of the elliptical concrete pipe will start at the upstream box manhole structure and progress in a downstream manner. Each joint treatment will begin with necessary cleaning and preparation of the existing concrete surface prior to drilling and installing grout ports. Crews will locate the reinforcing wires in the pipes and use electric hammer drills to install seventeen (17) grout ports into each pipe joint per the BDA Drawings. A penetrometer test of the bedding soil will be conducted at each joint at the 6 o-clock position through a grout hole, as defined in the project plans, prior to commencing the grouting operation at the joint.

Water will be injected into the installed ports in a sequential manner to pre-wet the pipe joint and to identify any leaking areas. These locations will be packed with oakum and asphaltic coating to seal the joint prior to grout injection. Hydrophilic polyurethane grout will then be pumped into each port around the joint using the prescribed methods outlined in the project plans and specifications.

The next stage of grouting at each pipe joint starts by removing the grout port installed for the hydrophilic grout and re-drilling the hole to a point just outside the concrete pipe wall. All seventeen (17) grout holes will be re-drilled in this process, flushed with water and a new grout port installed. Plural component acrylamide grout will be pumped, statically mixed and injected into each of the ports. We have assumed each port will take three (3) gallons of the mixture. Ports will be removed once grouting is complete, the hole re-drilled and then patched with a non-shrink 6,000 PSI mortar. Crystalline waterproofing will be applied to the surface of the mortar patches.

Ultra-fine (UF) cement grouting of each pipe segment will be initiated once the hydrophilic and acrylamide joint treatments have been completed. Drilling of injection points will be in the pattern and prescribed depths as outlined in the plans and specifications. ECI has included drilling each of the holes full depth with a hammer drill bit to facilitate successful installation of injection needle piping. Strata-Tech QC4 Cam Wall Lock Ports will be installed into each of the drilled holes and tightened into place with a wrench. UF cement grout will be mixed using a colloidal mixer to the proportions outlined in the plans (W/C ratio = 0.76 (approximately)) from a plant set-up located above ground. Mixed grout will be transferred down the existing manholes and into the pipe via hoses and slick-line to a secondary agitating tank/progressive cavity pump set-up underground to facilitate precise and accurate placement. ECI has calculated the grout quantity based on the instructions outlined in the plans and defined in the bid schedule. Grouting work will progress from the upstream MH location to the downstream portal. Ports will be removed once grouting is complete, the hole re-drilled and then patched with a non-shrink 6,000 PSI mortar.

Two penetrometer tests of the bedding soil will be conducted in each pipe segment through a UF grout hole, as defined in the project plans, prior to commencing the UF grouting operation in each segment of culvert. A minimum of seven days after the culvert segment grouting is complete, two penetrometer tests of the bedding soil will be conducted in each pipe segment through new test holes drilled through the pipe, as

defined in the project plans. The Engineer will use the pre-grout and post-grout test data to confirm bedding capacity improvements.

Crystalline waterproofing will be applied to existing cracks that meet the criteria outlined in the plans. These areas will be prepared by cleaning the concrete surface with a stiff bristle brush and compressed air flush. Waterproofing material will be placed with a brush in accordance with the manufacturer's application recommendations.
Crack injection will be in the areas identified in the plans and as marked in the field by the engineer. ECI will drill and install grout ports at a 45-degree angle and 5-inch spacings alternating sides along the length of the crack to be treated. Water will be injected into each port to verify the drill hole intersects the crack and to flush debris prior to grout injection. Polyacrylate grout will be mixed and injected into the ports at a rate of ¼ gallon per LF of crack. Ports will be removed once grouting is complete and patched with a non-shrink 6,000 PSI mortar.

Epoxy crack injection of larger cracks will be completed in the various areas outlined in the plans. ECI will use AV-522 to surface treat the crack area and secure the ports to the pipe. Once this material reaches its required set, the crack will be injected with AV-502. Ports will be removed after the injected epoxy has cured and the area restored as necessary.

ECI will repair the concrete pipe at 128 EA locations per the plans and specifications. Repairs will utilize dry-pack or troweled application methods to install the same 6,000 PSI repair mortar used to patch grout port holes.

Sincerely,
Engineering & Construction Innovations, Inc.

Shane McFadden, P.E.
President

Engineering & Construction Innovations, Inc.

RAYMOND ROAD CULVERT PIPE RESTORATION

Joint Chemical Grouting Work
Cementitious Grouting Work
Crack Sealing Work
and Quality Control Plan

Owner: WI DoT
Engineer: BDA Associates
Contractor: Engineering & Construction Innovations, Inc.

March 2020

7002 6th Street North ♦ Oakdale, MN 55128
Phone 651-298-9111 ♦ Fax 651-298-9113
ECI is an Equal Opportunity Employer

1. Material

1.1. Polyurethane Grout

- Asphalt Compound – Attachment A.
- Woven Oakum - Attachment A
- Part A: Hydrophilic Polyurethane Grout – Attachment B.
- Part B: Water.
- Part C: Acetone high grade 99% concentration.
- Part A:Part B ratio is 1:1.

1.2. Acrylamide Grout

- Part A: 98% Acrylamide Resin and 2% TEA Accelerator – Attachment C and Attachment D.
- Part B: 98% Water and 2% Ammonium Persulfate – Attachment F.
- Part C: Water.
- High strength mortar: MasterEmaco S-488 CE – Attachment G.
- Crystalline waterproofing – Attachment H.

1.3. Cementitious Grout

- Microfine cementitious material – Attachment I.
- Crystalline waterproofing – Attachment H.
- High strength mortar: MasterEmaco S-488 CE – Attachment G.

1.4. Cracks treatment

- Cracks less than 0.021” wide: Crystalline waterproofing – Attachment H.
- Cracks between 0.02” and 0.040” wide:
    - Part A: 98% Acrylic Resin and 2% TEA Accelerator – Attachment J and Attachment E.
    - Part B: 98% Water and 2% Ammonium Persulfate – Attachment F.
    - Part C: Water.
- Cracks greater than 0.040” wide: Epoxy Resin – Attachment K.

1.5. Strip Seals at joints in excess of 1.5 inches

- EPDM Rubber Gland and Stainless Steel Compression bands – Attachment L.

2. Drilling and Grouting Equipment

2.1. Polyurethane Grout

- Electric Hammer Drill.
- Grout Mixer and Pump.
- Grout Packers.

2.2. Acrylamide Grout

- Electric Hammer Drill.
- Grout Mixer and Pump.
- In-line Flow Meter.
- Grout Packers.

2.3. Cementitious Grout

- Electric Hammer Drill.
- Grout Mixer and Pump – CG600 Colloidal Mixer and Progressive Cavity Screw Pump, with a 13-cubic foot mixer and a 17-cubic foot agitated storage tank, 20-gallon per minute pump and an integral water meter on the mixing tank feed line.
- In-line flow meter.
- In-line pressure meter.
- Grout Packers.

2.4. Cracks treatment

- Electric Hammer Drill.
- Grout Mixer and Pump.
- Grout Packers/ports.

3. Drilling and Grouting - Work Plan

General Conditions and Preparatory Work

Specific safety controls will be submitted under ECI's General Safety Plan and Water Control / Diversion Plan under a separate cover.

ECI will monitor the weather on a daily basis and will coordinate activities and update schedule to avoid storm water drainage interference with grout operations.

Adjacent sewer utilities, if any, will be located prior to the grouting operations. Sewer utilities located within 4 feet of the storm sewer that is being worked on will be monitored during the grouting operations. The grout material will be colored with dye so if colored grout is observed, the grouting will stop and will be reported immediately to the Engineer.

The work limits of the pipe will be cleaned with pressure water and other tools. The asphalt compound patch at the joints will be removed to expose the concrete and removed/disposed according with ECI's Safety Plan.

All the cracks in the pipe will be inspected, measured (length and width), and marked per the following classification by treatment:

- Cracks with width less than 0.021 inches will be surface treated with crystalline waterproofing.
- Cracks with width greater than 0.021 inches and less than 0.040 inches will be injected with polyacrylate grout.
- Cracks with width greater than 0.040 inches will be injected with epoxy resin.

Drilling locations will be marked in the pipe as follows:

- Per joint according with Project Drawing 16A, see image 1.a.
- The cement grout holes (8 each) located between joints in the haunch area, see Image 1.b.
- Drill holes for crack interception (cracks with width greater than 0.021 inches).

Holes at the joint will be offset +/-3 inches in the pipe flange to intercept the center of the joint (see Image 2). The tolerance of hole location is included in the Quality Control Plan.

Joints will be inspected and measured. Joints greater in width than 1 ½ inches will be marked with a “G”, indicating the joint will require the installation of an internal joint seal.

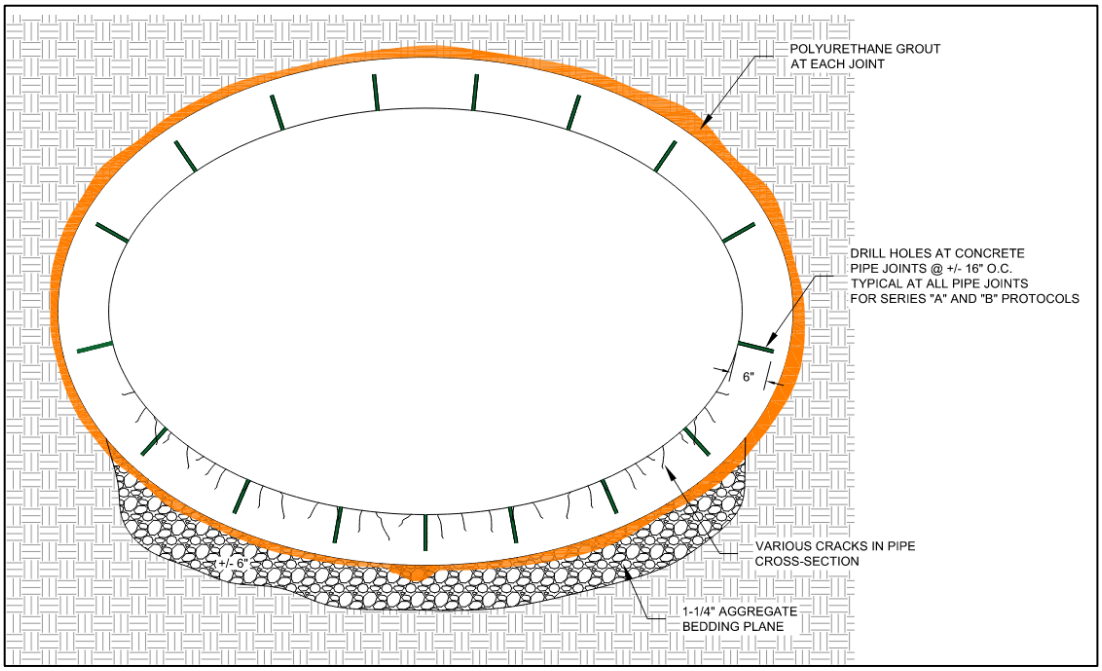


Image 1.a. Location of drill holes at each joint.

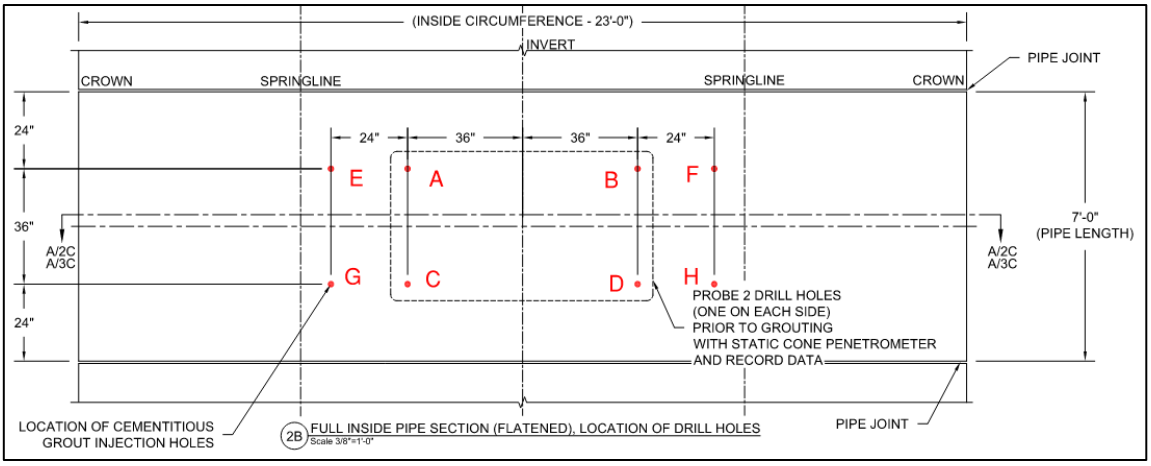


Image 1.b. Location of drill holes at the haunch area.

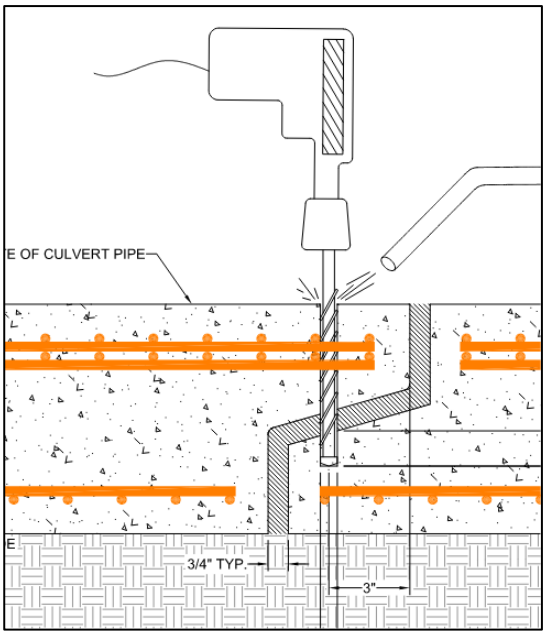


Image 2. Location of drill holes at each joint.

Existing reinforcement in the elliptical pipe will be located with a Ground Penetrating Radar (GPR) Device / Scanner (3" - 5" cover capacity) performed by a third party and supervised by ECI. The GPR scan will be extended 6 inches beyond the limits of the grout holes and cracks that require injection.

A static cone penetrometer will be calibrated onsite, per manufacturer recommendations. Readings of soil resistance at hole A of each joint and at the haunch area will be taken and recorded at depths of 6 inches, 12 inches and 18 inches into the soil, per the QC plan. These reading will be taken through the grout hole "A" location prior to placement of the Acrylamide Grout.

Mock Up Test Sections

The drilling and grouting process will be tested following the specific grouting processes defined in this document in two sections of the pipe (approx. 14 lineal feet) identified by and in the presence of the Engineer. The Engineer will utilize the Mock-up test section to determine the following:

- Verify bedding conditions
- Verify relative compaction of bedding material
- Verify grout penetration and grouted soil compaction/compressive strength
- Compare grout zone compaction (haunches) to non-grout zone compaction (6 o'clock position)
- Verify grout type, mix ratio, and injection quantities

- Verify adequately tests for soil resistance with static cone penetrometer.

All 8 grout holes of the Mock-up section will be tested before grouting and 3 new holes will be tested after grouting (see Image 10)

The Mock-up operation needs to be approved by The Engineer prior to continuing with the production work in the pipe. Any correction or change in the process will be included in the production work.

3.1. Drilling and Grouting Polyurethane Grout

Holes 5/8-inch diameter and 6 inches deep will be drilled at locations marked through the concrete pipe flange. Layout of the holes will be based on the design locations and the results of the GPR in order to avoid the existing reinforcement. Please note that some reinforcement may be encountered. All the drilling operations will follow OSHA regulations for dust control and silica fumes management, in accordance with the ECI Safety Plan.

Joints will be plugged with oakum rope impregnated/saturated with asphalt compound (See Attachment A).

After installation of the oakum/asphalt compound seal, the holes will be flushed with water. Injection ports/packers will be installed at the cleaned holes and pressurized water will be pumped at 10 psi per the project document requirements. The asphalt plug will be repaired as needed.

The holes will be tested with water under low pressure (5 psi), pumping at a rate of ¼ gallon per minute:

1. If pressure holds at 5 psi – the joint will be considered watertight and no polyurethane grout will be injected.
2. If pump pressure drops immediately or cannot sustain 5 psi for 1 minute, the joint will be grouted. The asphalt plug will be repaired as needed.

The polyurethane grout system will be contained in a portable wheeled wagon that will double as spill containment. The system will be in the pipe and located close to the placement. The water and air will be supplied from the surface and routed through the tunnel/pipe utilities. Lines, buckets, ½ gallon graduated pails, and specific tools will be marked in blue for the Part A (resin line), marked red for the Part B (water line) and marked green for Part C (Flushing material - Acetone high

grade 99% concentration). The liquid grouting components will be colored with dye to the corresponding color. The grouting system will be tested per QC Plan.

The hydrophilic polyurethane grout will be slowly mixed for 2 minutes prior to placement. Both components will be injected at a rate of ¼ gallon per minute at a maximum pressure of 20 psi. A maximum of 1 gallon of grout will be injected per port. If grout is witnessed at an adjacent port, the operation will move to the next port and the process repeated. The asphalt plug will be repaired as needed. Any grout spill/leakage will be cleaned and disposed per the ECI Safety Plan.

A container with acetone Part C will be available to clean and maintain the grout system. The resin line will be flushed with acetone once per working day. This material will be removed and disposed per the ECI Safety Plan.

The sequence of the grout process will follow the letters of the holes of Image 3, starting in the invert with hole “A” and continuing chronologically as noted in Image 3.

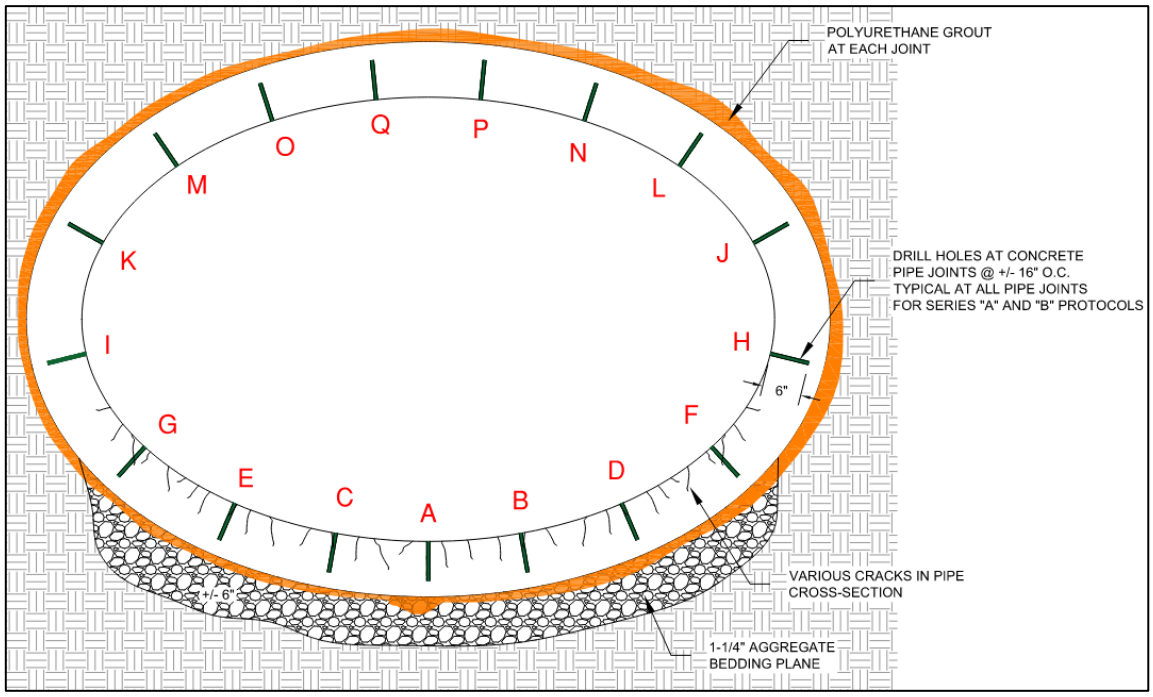


Image 3. Grout sequence.

3.2. Drilling and Grouting Acrylamide Grout

After the polyurethane sequence is completed at a joint and the grout is set, the grout ports will be removed. The 5/8-inch grout holes will be re-drilled at the same

location through the pipe and 3” – 5” into the soil (approx. total depth of drill 11.5” – 13.5”).

A static cone penetrometer test will be taken and recorded at hole “A” location of each joint at the depths previously indicated before injection of the acrylamide grout.

Holes will be flushed and cleaned with pressurized water and the joints will be monitored for leakage through the oakum/asphalt plugs. If any leakage occurs, the location will be re-injected with polyurethane according to the respective work plan.

The containers of part A and part B for the acrylamide grout will be located at the surface outside the tunnel, and the pumping system will be installed close to the placement. Totes, lines, buckets, ½ gallon graduated pails, and specific tools will be marked in blue for the Part A (resin line), marked red for the Part B (oxidizer line) and marked green for Part C (Flushing material - water). In the same way, components will be colored with dye. The grouting system will be tested per QC Plan.

Parts A and B for the acrylamide grout will be slowly mixed prior and during placement at each tote with pneumatic tote mixers.

Part A will be 98% acrylamide resin and 2% TEA Accelerator, blue dye colored.
Part B will be 98% water and 2% Ammonium persulfate, red dye colored.
Part C will be water, green dye colored.

Part A and B will be statically mixed and injected through surface mounted ports/packers following the sequence of Image 3 at a rate of ¼ gallon per minute and a maximum pressure of 40 psi. A maximum of 3 gallons of grout will be injected per hole. If acrylamide grout leaks up through pipe joint, pumping operations will stop for 2-3 minutes to let the grout set. The hole will be re-drilled and re-injected with at least 2 gallons of grout. Any grout spill/leakage will be cleaned and disposed per the ECI Safety Plan.

After one hour, the acrylamide grout will be sufficiently cured to allow re-drilling of the injection holes to a depth of 7 to 8 inches. The re-drilled holes will be flushed with air and water. After cleaning, the holes will be filled with mortar (MasterEmaco S 488) and compacted with a wooden dowel in three lifts to the surface of the pipe. A +/- 4” wide slurry coat of crystalline waterproofing slurry will be brush placed over the holes. The waterproofing patch can be placed anytime after the holes have been grouted.

Any remaining material will be cleaned and removed from the pipe. All the slicklines, pumps, and fittings will be flushed and cleaned as needed to guarantee continuity of operations.

3.3. Drilling and Grouting Cementitious Grout

Holes 3/4 inch diameter will be drilled at locations marked according with Image 1b and Image 4, to a depth of 6 inches below the culvert pipe for the grouting holes. The testing holes will be drilled through the pipe with no protrusion per the QC plan.

Before grouting, an auger bit will be used to take samples of soil at one of the drilled holes for grouting to a depth of one foot into the soil. Samples will be taken at each pipe sections on alternating sides of the pipes per Image 10.

Static cone penetrometer tests will be executed and recorded at 6 inches, 12 inches, and 18 inches into the soil per the QC Plan and Image 10, as follows:

- Readings prior to cementitious grouting: 1 set of readings at one of the grouting holes from the internal row, alternating sides.
- Readings after cementitious grouting: Additional holes will be drilled between rows in the same side where it was tested prior to grouting and will be drilled in the middle of the invert every other section of pipe.

Layout of the holes will be based on the design locations and the results of the GPR in order to avoid the existing reinforcement. Please note that some reinforcement may be encountered. All the drilling operations will follow OSHA regulations for dust control and silica fumes management, according with the ECI Safety Plan.

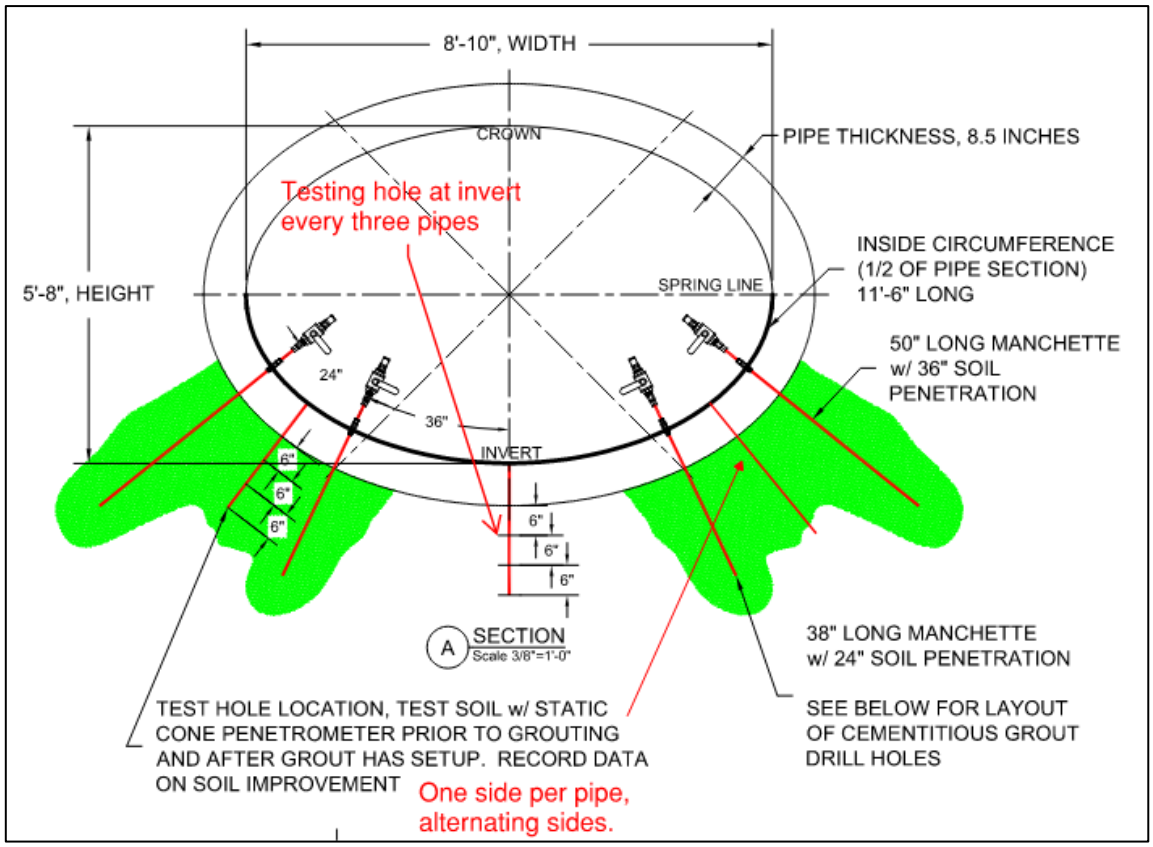


Image 4. Transversal view of the location of the holes for cementitious grouting.

Packers will be inserted in the 8 holes and secured into position. The ½" diameter manchette with drive tip will be inserted into the packer and driven to the required depth defined in Image 4. If resistance is encountered due to boulders, cobbles or coarse aggregate backfill, a solid steel rod or 3/8" hammer-drill bit will be used to clear passage. Once manchettes are placed, clearance will be checked with a plunging rod down and flushed as needed. The steel tip on solid manchette will be knocked off and sacrificed and the ferrule/ball valve will be installed. See Image 5.

Manchettes will be flushed with 1-2 gallons of water to a pressure of 25 psig to ensure grout acceptance and that interior leakage does not occur.

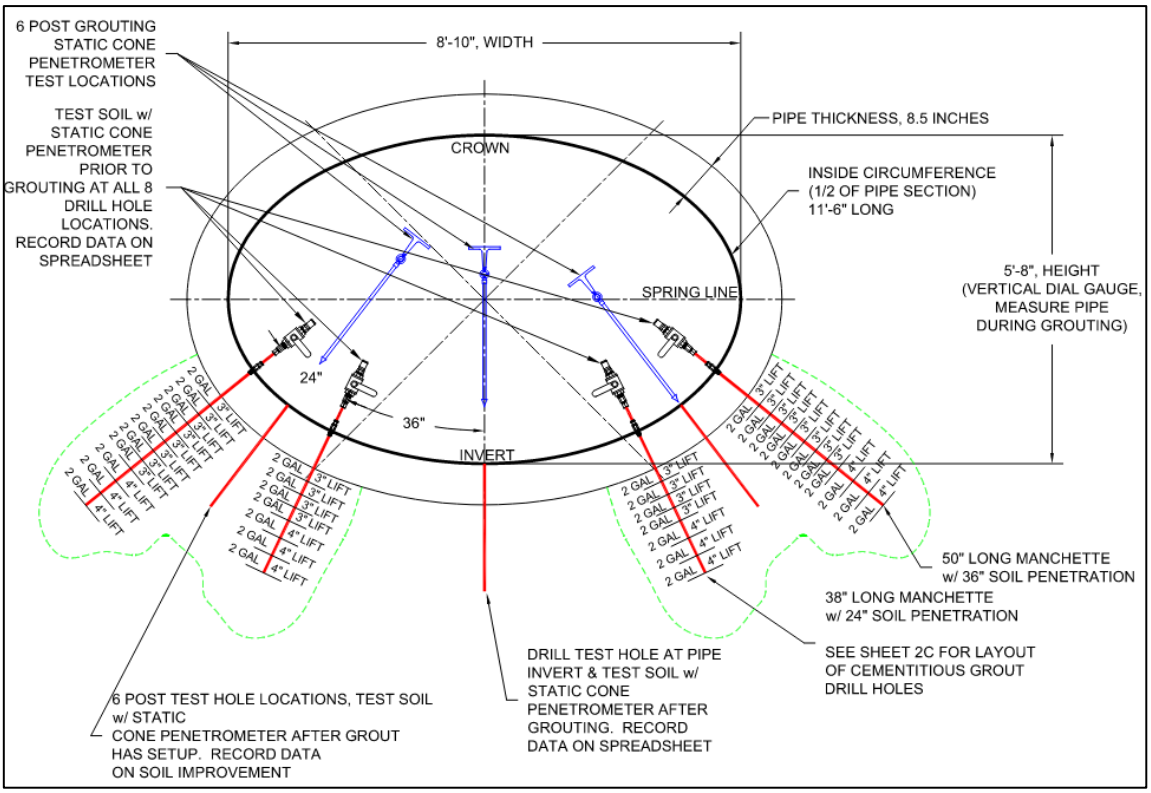


Image 5. Detail of manchettes installation and grouting process.

The mixer plant/pump and materials will be located at the surface outside the tunnel. A flow meter and pressure meter will be installed within 50 feet of placement. Gradations will be placed at 3 inches and 4 inches O.C. on the injection manchette as is showed in Image 5. The cementitious grout will be mixed using ultrafine cement and water at a 0.6 W/C ratio.

The ultrafine cementitious grout will be injected following the sequence of Image 1b, injecting the volume indicated in Image 5, in lifts from bottom to top, at a rate of ½ gallons per minute at 40 psig of pressure (injection pressure will be verified/corrected during mock-up test if invert lifting is observed). Refusal criteria will be met when pumping rate drops at ¼ gallons per minute at 30 psig, for 5 consecutive minutes. Once the hole is grouted, the packer will be capped.

After 3-5 days of curing time, packers will be removed and the holes will be re-drilled 6 inches, flushed, and dry-packed with grout in three lifts with hammer wooden dowel compaction. A +/- 4” wide coat of crystalline waterproofing slurry will be placed with a brush over the holes. The waterproofing patch can be placed at a later time, several joints at the same time, to accommodate the general schedule.

Any grout spill/leakage will be cleaned and disposed per the ECI Safety Plan. All the slicklines, pumps and fittings will be flushed and cleaned as needed to guarantee continuity of operations.

3.4. Crack Treatment

Concrete surface will be cleaned, scraped and prepared to treat.

All the cracks detected during the inspection will be marked depending on their width and treatment.

3.4.1. Cracks with width less than 0.021 inches will be surface treated with crystalline waterproofing, per manufacturer recommendations. The crystalline slurry will be brush applied in two coats of ± 1/6" thick, approx. 3 inches on each side of the crack. The application of the second coat will be at least 3 hours after the first coat.

3.4.2. Cracks with width greater than 0.021 inches and less than 0.040 inches will be injected with polyacrylate grout.

Holes 5/8" diameter will be drilled per the instructions below (see Image 6a and 6b):

- Identify existing reinforcing with GPR scanner survey
- Mark spots for hammer drilling along crack/joint length
- Drill hole locations will be 4" to 5" out, on each side of the crack, approx. 6-8 inches on center, can use alternating pattern "x"=6", z=8" to 10".
- Drill holes at a 45º angle from surface of the concrete to a depth +/- 1" past the crack/joint
- Diagonal drill depth will be approx. 10".

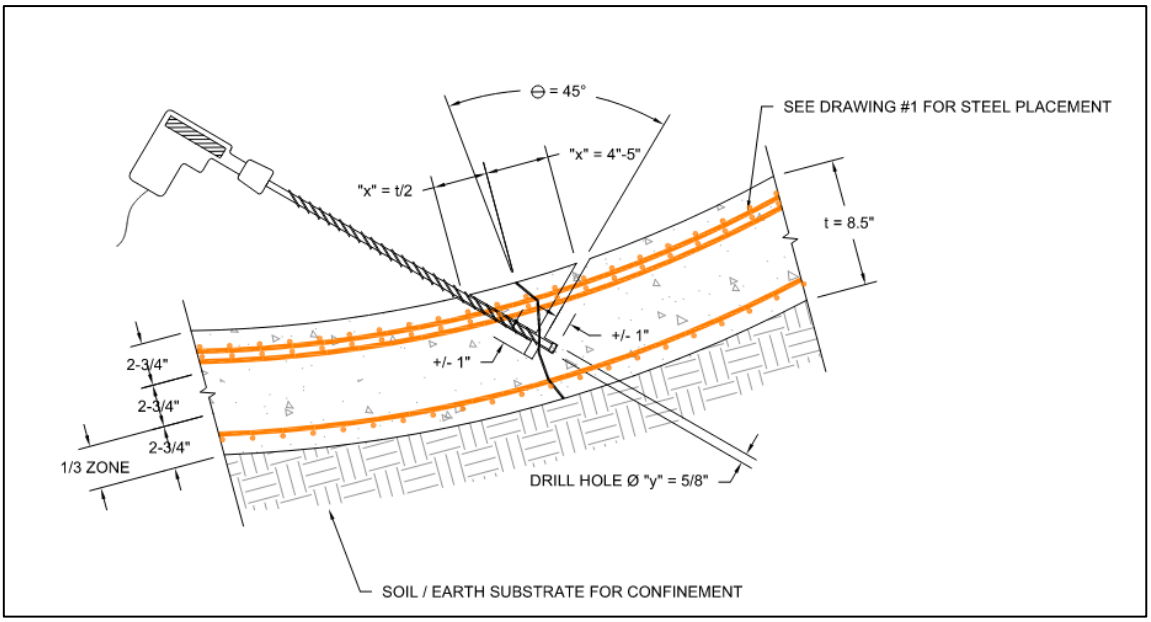


Image 6a. Location of drill holes for crack repair.

Key:
t = WALL / SLAB THICKNESS
1/3t = INTERCEPTION ZONE IN CRACK SECTION
x = MIN. DISTANCE FROM DRILL HOLE TO CRACK SHALL BE BETWEEN t/2 +/- (t/6)
⊖ = DRILL ANGLE TO SUBSTRATE SHALL TYPICALLY BE 45° AND CAN VARY +/- 15°
y = DRILL HOLE DIAMETER CAN BE 1/4", 3/8", 1/2", 5/8", AND 3/4"
t/2 = CENTERLINE OF ELEMENT
w = CRACK WIDTH
z = SPACING OF DRILL HOLES ALONG CRACK LENGTH SHALL BE BETWEEN t/2 to 2/3t

Image 6b. Location of drill holes for crack repair.

After drilling, the holes will be cleaned of dust/debris. Packers will be placed and tightened into the 5/8" holes. The cracks will be flushed per the QC Plan procedure.

The polyacrylate grout system will be contained in a portable wheeled wagon that will double as spill containment. The system will be in the tunnel and located close to the placement. The water and air will be supplied to from the surface through the tunnel/pipe utilities. Lines, buckets, ½ gallon graduated pails, and specific tools will be marked in blue for the Part A (acrylic resin line), marked red for the Part B (water + ammonium persulfate line) and marked green for Part C (Flushing material - water). In the same way, components will be colored with dye. The grouting system will be tested per the QC Plan.

The polyacrylate grout will be injected at a maximum continuing pumping pressure of 200 psig until mixed grout extends half way to each adjacent port, see Image 7.

Once grout communication is observed the pump nozzle will be moved to the next adjacent packet. This will continue until all packers have been injected. If resistance to chemical grout flow is being recognized at an individual packer, the grout pumping pressure can be allowed to increase to a maximum of 700 psig. If grout is not flowing through a packer, it can either be flushed with water or abandoned and a new hole drilled adjacent to it.

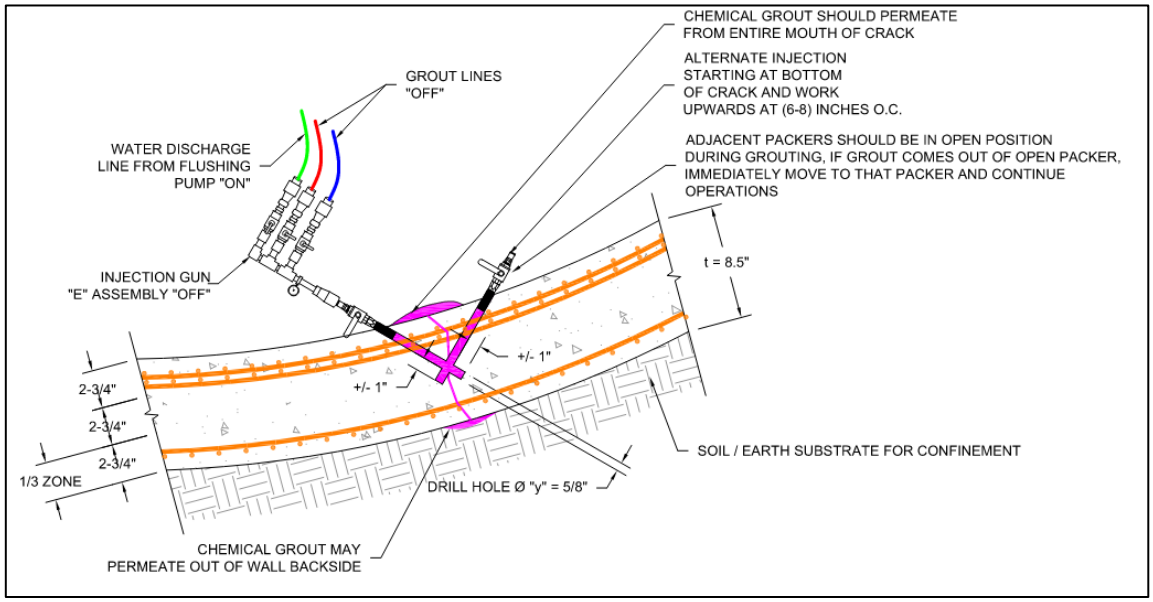


Image 7. Polyacrylate grout injection detail.

Any grout spill/leakage will be cleaned and disposed per ECI Safety Plan. All the slicklines, pumps and fittings will be flushed and cleaned regularly as needed.

After the polyacrylate grout has set/gelled the packers will be removed and the drill holes plugged and abandoned with crystalline mortar per the manufacturers recommendations.

3.4.3. Cracks with width greater than 0.040 inches will be injected with epoxy resin.

Epoxy injection ports will be centered over the concrete cracks at 6” – 8” O.C. Epoxy paste will be placed over the crack approx. 2” – 3” wide and approximately 1/8” thick and over the ports sides to ensure against leakage, see Image 8a and 8b.

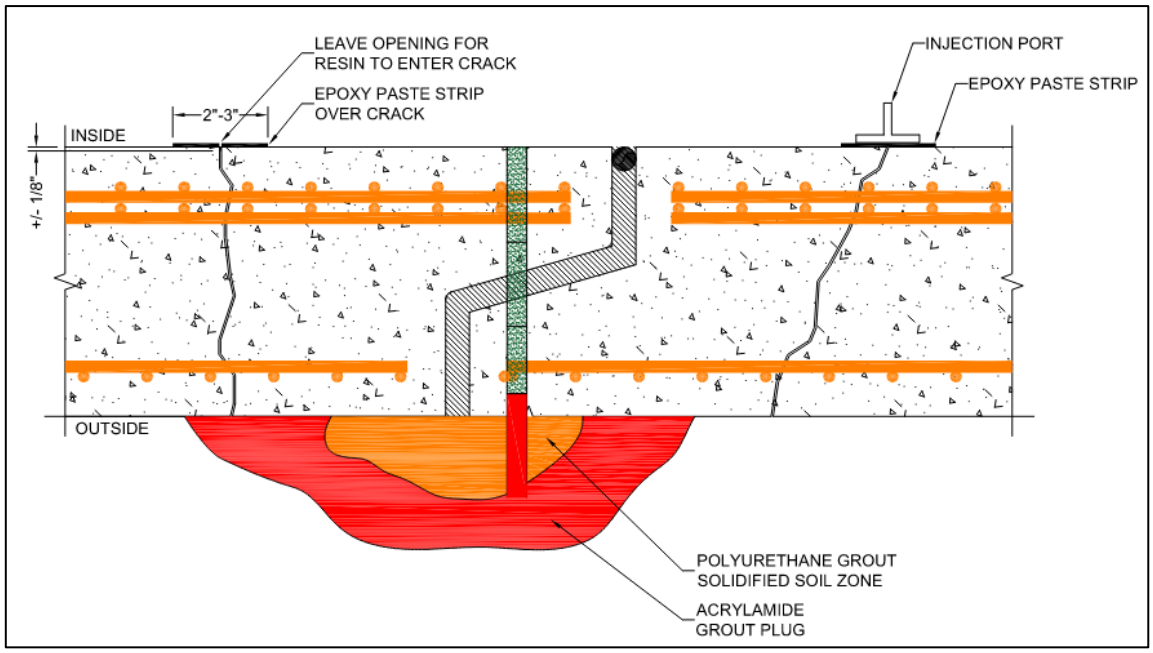


Image 8a. Epoxy resin grout injection detail.

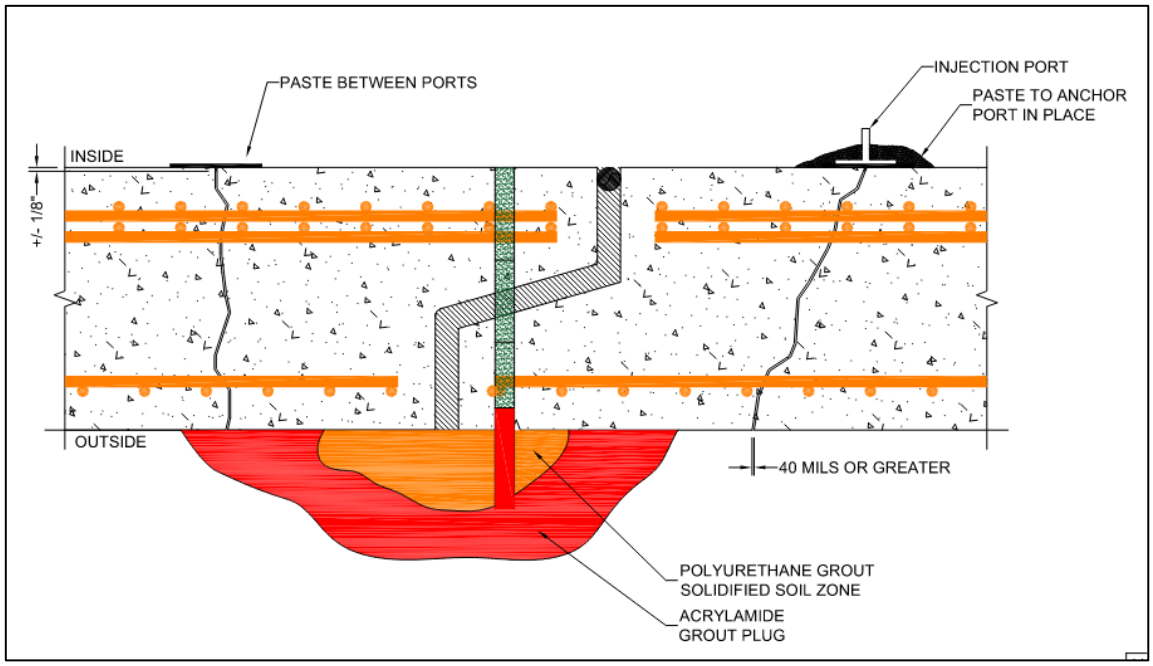


Image 8b. Epoxy resin grout injection detail.

The epoxy resin components will be mixed and pumped with a chemical grout pump at ± 50 psig and at ¼ gallons per minute or less. When epoxy flows from adjacent port, injection will be moved to the next line. Ports will be crimped/chipped/grinded after injection is done.

3.5. Joint Seals at Joint in excess of 1.5 inches

The joints will be grouted with polyurethane and acrylamide grout per the respective procedure of this Submittal prior the installation of the Joint Seals. Once the Joint and Cementitious grouting procedures are complete, HydraTite internal joint seals will be place at each joint where the joint opening is in excess of 1.5". The joint seals will be placed per the manufacturers recommendations (see Image 9a and 9b).

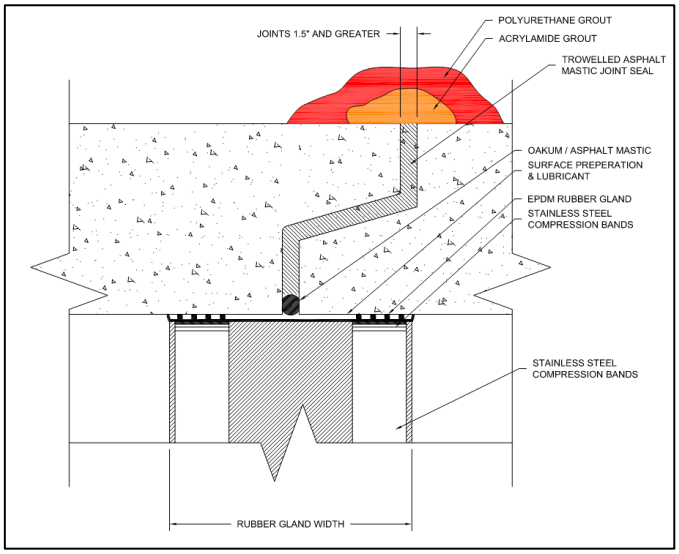


Image 9a. Strip seal joint in excess of 1.5 inches.

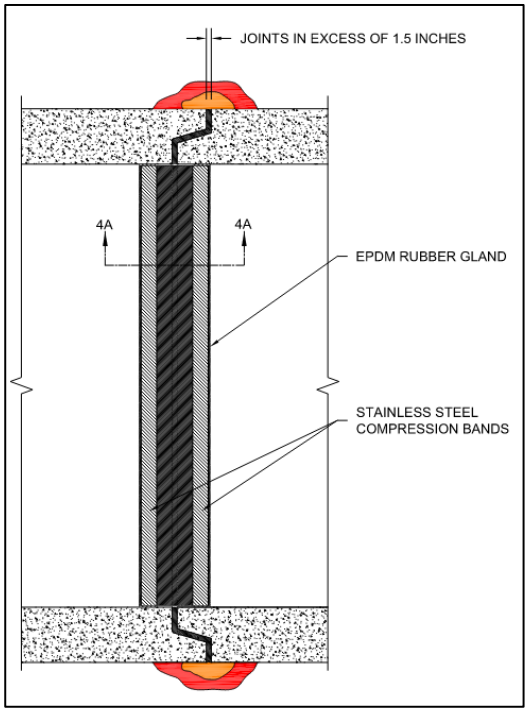


Image 9b. Strip seal joint in excess of 1.5 inches.

4. Quality Control Plan

4.1. Drilling and Grouting Polyurethane Grout

All the material will be weighted after delivery, graduated totes and pails will be used to control volume placed.

The working area will be cleaned and GPR scanned prior any drilling activity. Location of the holes and sequence of grouting is showed in images 1-3 of the work plan.

The drilling process will be performed carefully to not perforate the existing reinforcement. If reinforcing is found during drilling, the hole will be abandoned with cementitious mortar and will be relocated with ± 1" of tolerance.

The drill will be equipped with a stop to set and control the particular drill depth.

The holes considered watertight during the low-pressure water test of the holes will not be grouted. These holes will be marked in pink.

The polyurethane grout system will be marked in blue for the Part A (resin line), marked in red for the Part B (water line) and marked in green for the Part C (flushing line). The liquid product dyed the same corresponding color.

The grout system will be tested prior to every shift. The system will pump each component into a measuring cup to ensure proper 1:1 ratio. The ratio tolerance for the Polyurethane grout is up to 20%. If the ratio differs by more than 20%, the viscosity of the polyurethane will be adjusted by heating. The pumping will be repeated until the result is within tolerance. Once the pumping rate is adjusted, the two components will be mixed to obtain the gel time. This test will be recorded on QC Forms (Attachment D). The temperature of the components will be adjusted to get the gel time between 30 seconds and 3 minutes, depending of requirements and placing conditions:

1. To lengthen gel time: reduce temperature of both components by 20º F.
2. To shorten gel time: increase temperature of both components by 20º F.

1 gallon of polyurethane will be injected per hole, volume will be controlled using graduated pails with ½ gallon increments.

QC tests and other recorded parameters (air and material temp, volume, pumping rate, hole pressure, etc.) will be recorded by the Site Project Engineer or designated QA representative on the QC Forms (Attachment D), per the frequency showed in Table 1. QC Forms will be submitted to The Engineer weekly.

Table 1. Frequency of parameters recording

Drilling Log	Per hole
Grout system Test	Prior every shift
Grouting Log	Per hole
Ambient Temperature	Prior every shift
	If 50 F < Temp < 80 F - every hour
Component A and B Temperature	Prior every shift
	If 50 F < Temp < 80 F - every hour
Volume of grout	Per hole
Pumping rate	Per hole
Holes watertight	Per joint

ECI will have a Project Engineer or Superintendent (Supervisor) on site full time during production and work operations to ensure that the drilling and grouting work is completed in compliance with the specifications and this work plan.

Cold weather management will follow the manufacturer recommendations for all the products used.

4.2. Drilling and Grouting Acrylamide Grout

The crew involved in the acrylamide operations will be trained and certified by the manufacturer. All the material storage units will be checked for volume to ensure that consumption rates are equal during the grouting operations.

The depth of the re-drilled hole will be controlled using stops on the drill. Drill depths will not exceed 13.5” or 5” beyond the outside of the pipe.

A static cone penetrometer will be used to measure soil resistance in hole A of each joint at depths of 6 inches, 12 inches and 18 inches before acrylamide grouting. Readings will be recorded on the QC Form (Attachment D).

During the pressurized water flush of the holes, the oakum/asphalt plug will be monitored for water leakage. If any leakage is detected, polyurethane grout will be re-injected.

The acrylamide grout system will be marked in blue for the Part A (resin line), marked red for the Part B (oxidizer line) and marked in green for the Part C (flushing line). Mixing materials will be dyed the same color.

The grout system will be tested prior every shift. The system will pump each component into individual measuring cups to ensure proper 1 to 1 ratio. The tolerance will be ± 5%. If the ratio differs more than 5%, adjust pump stroke length. The pumping will be repeated until the result is within tolerance. Once the pumping rate is adjusted, the two components will be mixed to observe the gel time. This test will be recorded in QC Forms of Attachment D. The amount of TEA accelerator and ammonium persulfate will be adjusted to obtain a gel time between 30 seconds and 5 minutes, depending of requirements and placing conditions:

1. To lengthen gel time: reduce TEA accelerator by 20% into part A, reduce ammonium persulfate by 20% in part B.
2. To shorten gel time: increase TEA accelerator by 20% into part A, increase ammonium persulfate by 20% in part B.

Re-drilling, grouting/re-grouting, tests and other parameters will be recorded by the Site Project Engineer or Superintendent in the QC Forms of Attachment D, per the frequency showed in Table 2. QC Forms will be submitted to The Engineer weekly.

Table 2. Frequency of parameters recording

Drilling Log	Per hole
Grout system Test	Prior every shift
Grouting Log	Per hole
Static Cone penetrometer	Per joint
Ambient Temperature	Prior every shift
	If 50 F < Temp < 80 F - every hour
Component A and B Temperature	Prior every shift
	If 50 F < Temp < 80 F - every hour
Volume of grout	Per hole
Pumping rate	Per hole

Delivery, handling and storage of the acrylamide liquid and ammonium persulfate powder will follow a strict safety procedure. These materials will be kept completely separated from one another due to their extremely high reactivity.

Hot/Cold weather management will follow the manufacturer recommendations for all products used. All components will be protected from inclement weather conditions, keeping the storage temperature between 40º F and 120º F. If ambient temperature exceeds 80º F, a retarder can be used to control set time of the acrylamide grout. The acrylamide resin will be protected from sun exposure.

Six grout cubes (ASTM 109) of the high strength mortar used to plug the holes will be taken during the mockup placement. This will be done for reference but not during production operations.

4.3. Drilling and Grouting Cementitious Grout

The working area will be cleaned and GPR scanned prior any drilling activity. Location of the holes and sequence of grouting is showed in images 1b and 4 of the work plan.

The drilling process will be performed carefully to not penetrate the existing reinforcement. If reinforcement is found during drilling, the hole will be abandoned with cementitious mortar and will be relocated within 4”.

The mock-up section tests will be executed on two pipe sections to verify the plan and make any necessary corrections or modifications. The initial injection pressure will be 40 psig and the invert will be monitored for lifting, pressure will be adjusted as needed.

Before grouting, an augured bit will be used to take samples of soil at one of the drilled holes for grouting, one foot into the soil, alternating sides, per Image 10.

A static cone penetrometer will be used to measure soil resistance at 6 inches, 12 inches and 18 inches into the soil, as showed in Image 10, as follow:

1. Readings before cementitious grouting: 1 set of readings at one of the grouting holes from the internal row, alternating sides.
2. Readings after 3-5 days of curing cementitious grout: additional holes will be drilled between rows in the same side where it was tested prior grouting, alternating sides, and also drilled in the middle of the invert every other section of pipe.

Readings will be recorded in the QC Form, Attachment D. Testing holes will be abandoned using the high strength mortar from Attachment G.

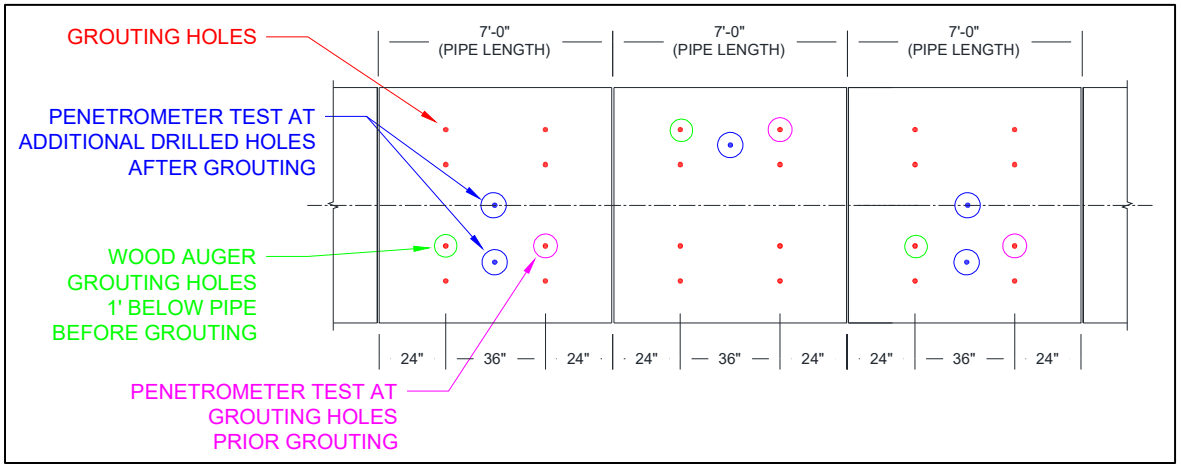


Image 10. Location and sequence of penetrometer tests.

Volume of water and microfine cement will be monitored and recorded to check W/C ratio per design. Volume injected of the cementitious grout will be recorded per lift with the flowmeter.

Table 3. Tests/QC Monitoring

Description	Frequency
Drilling Logs	per hole
Grouting Logs	per hole
Viscosity	One per shift
Specific Gravity	One per shift
Bleed Test	At Mock-up Test Section only
Grout cubes	One per shift
Ambient Temperature	Prior every shift
	If 50 F < Temp < 80 F - every hour
Component A and B Temperature	Prior use
	If 50 F < Temp < 80 F - every hour
Volume of grout	per lift/hole
Pumping rate	per hole
Holes watertight	per hole

Hot/Cold weather management will follow the manufacturer recommendations for all products used. All components will be protected from inclement weather conditions, keeping the storage temperature between 40º F and 70º F.

Six grout cubes (ASTM 109) of the cementitious grout will be taken per shift and tested at 3, 7 and 28 days, 3 cubes will be kept on hold.

4.4. Crack Treatment

All the material will be weighted after delivery, graduated pails will be used to control volume placed.

Concrete surface will be cleaned, scraped and prepared to treat.

All the cracks will be measured in length and width and classified by treatment as mentioned in Item 3.4. Records of the length and width per section of the pipe will be kept in the QC forms from Attachment D.

4.4.1. For cracks with width less than 0.021 inches, crystalline waterproofing will be applied by brush, per manufacturer recommendations, in two coats of ± 1/16” thick, approx. 3 inches on each side of the crack. The application of the second coat will be at least 3 hours after the first coat. The material will be protected by not accessing through the area treated for at least 1 day or by placing a plank board in the top.

4.4.2. Cracks with width greater than 0.021 inches and less than 0.040 inches will be injected with polyacrylate grout.

The working area for the cracks with width greater than 0.021 inches will be GPR scanned prior any drilling activity.

The drilling process will be performed carefully to not perforate the existing reinforcement. If rebar is found during drilling, the hole will be abandoned with cementitious mortar and will be relocated.

Drill holes will be cleaned by pressurized air/water

The cracks will be flushed starting at 100 psig of pressure, ensuring that water permeates from crack 6 inches each direction centered on drill hole. If water does not permeate from crack, the pressure will be increased in 100 psig increments up to 700 psig when operations will stop to not frack the concrete. This implies that

the crack was not intercepted, the residual water pressure will release, packer removed, and hole will be re-drilled deeper into cross-section. This process will be repeated until flushing water has permeated from crack, flushing for 2 minutes. Holes that do not allow water penetration will be marked as dead holes. In cracks wide enough to allow visually, free-flowing water, un-raveled oakum will be placed into mouth of the crack to temporarily stop the un-restricted flow of water.

The grout system will be tested prior every shift. The system will pump each component into a measuring cup to ensure proper 1 to 1 ratio. The tolerance will be ± 10%. If the ratio differs more than 10%, adjust pump stroke length. The pumping will be repeated until the result is within tolerance. Once the pumping rate is adjusted, the two components will be mixed to observe the gel time. This test will be recorded in QC Forms of Attachment D. The amount of TEA accelerator and ammonium persulfate will be adjusted to obtain a gel time between 2 seconds and 3 minutes, depending of requirements and placing conditions:

1. To lengthen gel time: reduce TEA accelerator by 20% into part A, reduce ammonium persulfate by 20% in part B.
2. To shorten gel time: increase TEA accelerator by 20% into part A, increase ammonium persulfate by 20% in part B.

Re-drilling, grouting/re-grouting, tests and other parameters will be recorded by the Site Project Engineer or Superintendent in the QC Forms of Attachment D, per the frequency showed in Table 4. QC Forms will be submitted to The Engineer weekly.

Table 4. Frequency of parameters recording

Drilling Log	Per crack
Grout system Test	Prior every shift
Grouting Log	Per crack
Ambient Temperature	Prior every shift
	If 50 F < Temp < 80 F - every hour
Component A and B Temperature	Prior every shift
	If 50 F < Temp < 80 F - every hour
Volume of grout	Per crack
Pumping rate	Per crack

Hot/Cold weather management will follow the manufacturer recommendations for all products used. All components will be protected from inclement weather conditions, keeping the storage temperature between 40º F and 120º F. If ambient

temperature exceeds 80º F, a retarder can be used to control set time of the polyacrylate grout.

4.4.3. Cracks with width greater than 0.040 inches will be injected with epoxy resin.

Epoxy resin components A and B will be mixed and pumped with the chemical grout pump at ± 50 psig and at ¼ gallons per minute or less. Pressure and total volume injected will be tracked and recorded in the QC forms – Attachment D.

Attachment A – Asphalt Compound Product Data Sheet

PURE ASPHALT
MANUFACTURER OF SPECIALTY COATINGS SINCE 1927

PRODUCT DATA

3300 W. 31ST STREET
CHICAGO, IL 60623
PHONE: 773.247.7030
FAX: 773.247.7066
WWW.PUREASPHALT.COM

SEWER JOINT COMPOUND #44

DESCRIPTION

Sewer Joint Compound consists of asphalt, plasticizers, mineral fillers and other mineral matter, thoroughly mixed to a homogeneous consistency.

Sewer Joint Compound is a cold applied mastic joint sealer for pipe. It is a bituminous material of such consistency that it can be applied to the joints with a trowel when the temperature of the air is between 20°F and 100°F. The compound adheres to concrete or clay pipe, making a watertight seal that will not flow, crack or become brittle when exposed to the atmosphere.

PHYSICAL CHARACTERISTICS

Color	- Black
Consistency-Cone Penetration @77°F	- 175-300
Weight per Gallon	- 8.3-9.0
Loss on Heating, 325°F, 5 hrs., 50g	- 20% max.
Inorganic Content [complete burn 1200-1400 °F]	- 15-40%
Flow at 140°F, centimeters	- 0
Pliable at 0°F	- Yes

APPLICATION

Sewer Joint Compound is designed for trowel application. The compound shall spread readily without drawing or pulling when applied to concrete, tile or steel surfaces. Sewer Joint Compound is available in three different consistencies (Summer, Spring-Fall, and Winter Grades).

Requires no heating, melting or mixing on the job.

PACKAGING

Available in 5-gallon pails and 55-gallon drums.

SPECIFICATION

Meets specification for Colorado, Illinois, Indiana, Iowa, Maryland, Minnesota, Nebraska, Oklahoma, Pennsylvania, South Carolina, Tennessee, Virginia, West Virginia and Wisconsin. Summer Grade meets specification for Kansas and Missouri. Meets Federal specification SS-C-153C Type I, ASTM D4586-93.

The information presented herein is based on the data available and is believed to be correct. However, nothing stated in this bulletin is to be taken as a warranty, expressed or implied regarding the accuracy of the information of the use of our product used singly or in conjunction with other products

PURE ASPHALT
MANUFACTURER OF SPECIALTY COATINGS SINCE 1927

PRODUCT DATA

3300 W. 31ST STREET
CHICAGO, IL 60623
PHONE: 773.247.7030
FAX: 773.247.7066
WWW.PUREASPHALT.COM

SEWER JOINT COMPOUND

DESCRIPTION

- A ready mixed cold applied compound for sealing concrete pipe joints.
- It is manufactured from specially selected and blended asphalts, carefully compounded with inert fillers and blended solvents to trowel consistency.
- It has excellent adhesion to clean concrete surfaces.
- It has high cohesive strength and hardens to a tough elastic seal.

CHARACTERISTICS

Physical State....., *Black, Plastic*

Weight per gallon..... *Appx. 10 lbs.*

Drying time to touch.... *2 Hours*

Consistency..... *Homogenous mastic for trowel application Properties of Dry Film..Durability under extreme weather conditions; will not check or crack, sag or flow. Resistance to water, oxidation and aging.*

APPLICATION

- This compound is designed for trowel application. Jute or hemp may be used for the original caulking, subject to the opinion of the supervising engineer.
- Requires no heating, melting or mixing on the job.
- No extra tools or equipment required.
- Will not freeze or melt – can be used in all temperature conditions.

ORDERING INFORMATION

Specify **winter**, **spring/fall** or **summer** grade when ordering. State certification available upon request with order.

TABLE SHOWING APPROXIMATE QUANTITIES OF SEWER JOINT COMPOUND FOR CONCRETE *SOCKET JOINT PIPE*

Pipe Size	Cubic Feet of Annular Space	Pounds of Compound Per Joint
21"	.05	3.75 lbs.
24"	.063	4.63 lbs.
27"	.084	6.30 lbs.
30"	.097	7.28 lbs.
33"	.111	8.33 lbs.
36"	.127	9.53 lbs.
42"	.21	15.75 lbs.
48"	.26	19.50 lbs.
54"	.34	25.50 lbs.
60"	.40	30.00 lbs.
66"	.47	36.05 lbs.
72"	.56	42.00 lbs.
78"	.62	46.50 lbs.
84"	.79	59.25 lbs.
90"	.80	60.00 lbs.
96"	.81	60.75 lbs.
102"	.96	72.00 lbs.
108"	1.08	81.00 lbs.

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SEWER JOINT COMPOUND #44

DESCRIPTION

Sewer Joint Compound consists of asphalt, plasticizers, mineral fillers and other mineral matter, thoroughly mixed to a homogeneous consistency.

Sewer Joint Compound is a cold applied mastic joint sealer for pipe. It is a bituminous material of such consistency that it can be applied to the joints with a trowel when the temperature of the air is between 20°F and 100°F. The compound adheres to concrete or clay pipe, making a watertight seal that will not flow, crack or become brittle when exposed to the atmosphere.

PHYSICAL CHARACTERISTICS

Color	- Black
Consistency-Cone Penetration @77°F	- 175-300
Weight per Gallon	- 8.3-9.0
Loss on Heating, 325°F, 5 hrs., 50g	- 20% max.
Inorganic Content [complete burn 1200-1400 °F]	- 15-40%
Flow at 140°F, centimeters	- 0
Pliable at 0°F	- Yes

APPLICATION

Sewer Joint Compound is designed for trowel application. The compound shall spread readily without drawing or pulling when applied to concrete, tile or steel surfaces. Sewer Joint Compound is available in three different consistencies (Summer, Spring-Fall, and Winter Grades).

Requires no heating, melting or mixing on the job.

PACKAGING

Available in 5-gallon pails and 55-gallon drums.

SPECIFICATION

Meets specification for Colorado, Illinois, Indiana, Iowa, Maryland, Minnesota, Nebraska, Oklahoma, Pennsylvania, South Carolina, Tennessee, Virginia, West Virginia and Wisconsin. Summer Grade meets specification for Kansas and Missouri. Meets Federal specification SS-C-153C Type I, ASTM D4586-93.

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- It has excellent adhesion to clean concrete surfaces.
- It has high cohesive strength and hardens to a tough elastic seal.

CHARACTERISTICS

Physical State....., *Black, Plastic*

Weight per gallon..... *Appx. 10 lbs.*

Drying time to touch.... *2 Hours*

Consistency..... *Homogenous mastic for trowel application Properties of Dry Film..Durability under extreme weather conditions; will not check or crack, sag or flow. Resistance to water, oxidation and aging.*

APPLICATION

- This compound is designed for trowel application. Jute or hemp may be used for the original caulking, subject to the opinion of the supervising engineer.
- Requires no heating, melting or mixing on the job.
- No extra tools or equipment required.
- Will not freeze or melt – can be used in all temperature conditions.

ORDERING INFORMATION

Specify **winter**, **spring/fall** or **summer** grade when ordering. State certification available upon request with order.

TABLE SHOWING APPROXIMATE QUANTITIES OF SEWER JOINT COMPOUND FOR CONCRETE *SOCKET JOINT PIPE*

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24"	.063	4.63 lbs.
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33"	.111	8.33 lbs.
36"	.127	9.53 lbs.
42"	.21	15.75 lbs.
48"	.26	19.50 lbs.
54"	.34	25.50 lbs.
60"	.40	30.00 lbs.
66"	.47	36.05 lbs.
72"	.56	42.00 lbs.
78"	.62	46.50 lbs.
84"	.79	59.25 lbs.
90"	.80	60.00 lbs.
96"	.81	60.75 lbs.
102"	.96	72.00 lbs.
108"	1.08	81.00 lbs.

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MATERIAL SAFETY DATA SHEET

MANUFACTURER: Pure Asphalt Company
3300 W. 31st Street
Chicago, IL 60623

Technical product information:
(773) 247-7030
Emergency spill and health information:
(800) 424-9300

DATE PREPARED: 11/02/09
REPLACES DATE: 11/30/06

PRODUCT NAME: Mineral Spirits Cutback Asphalt

PRODUCT NUMBERS/NAMES: 007, 007-SK, 008, 040F, 048, 066, 074, 075-MP, 075-Dampproofing, 077-VS, 079, 080F, 080F9, 080P, 081B, 081T, 083, 084P, **084WFM**, 085, 087, 088, 089, 090, 899, 2000,3000,4000,4630 6020, 6025, 6029, 7000, 710-MP, 715-STIP-NR, 733, 740-B, 745B, 749, 752, 7581, 760, 770MP, 825 MP, 877, 902, 931, 932, 933, 933-P, 934, D41, SJC-SEWER JOINT COMPOUND, J-180, MIRROR MASTIC, TSS-SOUN.

SECTION II - COMPONENT DATA

HAZARDOUS INGREDIENTS:

COMPONENT	CAS NUMBER	%	OSHA - PEL	ACGIH-TLV	OTHER
Petroleum Asphalt	8052-42-4	40 - 90	* N/E	5 mg/m3, 8-hr.TWA (asphalt fumes)	Niosh 5 mg/m3
Medium Aliphatic, Petroleum Distillate Mineral Spirits	8052-41-3	10 – 60	400 ppm, 8hr TWA (pet distillates)	100 ppm, 8hr TWA (Stoddard solv.)	NIOSH, 350mg/m3 10hr TWA

* OSHA has not established a specific PEL for asphalt fumes. They are considered as "particulate not otherwise regulated" with a PEL of 5 mg/m3 for the respirable dust and fraction and 15 mg/m3 for total dust fraction.

SECTION III - PHYSICAL DATA

Melting point (F):	Not determined
Specific gravity (H_20=1):	0.87 - 0.96 for product
Vapor pressure (mmHg @ 20 C):	Not determined, 2.9 for mineral spirits
Evaporative rate (Ethyl Ether = 1):	Not determined, 70° for mineral spirits
Appearance and odor:	Black or brown liquid with petroleum odor
Boiling point (F):	Not determined, 300° for mineral spirits
Percent volatile by volume:	25 -75
Vapor density (air = 1):	Not determined, 4.9 for mineral spirits
Solubility in water:	Insoluble
PH:	Not determined

SECTION IV - FIRE AND EXPLOSION DATA

Flash point (F): Not determined, 103° for mineral spirits. (Flash point for product is 103°)
Method used: Tag closed cup

Auto ignition temperature (F): Not determined
Flammability limits: LEL: Not determined, 0.9 for mineral spirits
UEL: Not determined, 6.7 for mineral spirits

Extinguishing media: Foam, carbon dioxide, or dry chemical.

Special fire-fighting instructions: Do not direct water on substance. Treat as a fuel oil fire. Water may used to cool closed containers. In a substance fire, use self-contained breathing apparatus.

Unusual fire and explosion hazards: Material is combustible. Vapors of mineral spirits are heavier than air and may travel along the ground or are moved by ventilation to locations distant from the point of material handling. To prevent ignition, avoid smoking, keep away from heat, open flame, or sources of static or electrical sparking. Use explosion proof motors and equipment. Tank trucks or other containers should be grounded and/or bonded when material is transferred.

SECTION V - HEALTH HAZARD DATA

Primary routes of exposure: Inhalation, skin contact, and eye contact.
Health hazards (including acute and chronic effects and symptoms of overexposure)
Acute:
Inhalation: Can cause dizziness, headaches, loss of appetite, nausea, and possibly nose, throat and mucous membrane irritation. Solvents can effect central nervous system, including general weakness, laps of memory, jitters, unconsciousness or effects of mimicking drunkenness.

Skin Contact: Prolonged or repeated contact with cold product can cause drying and irritation. Long term skin exposure to asphalt fumes can increase sensitivity to sun and cause skin discoloration.
Eye contact: May cause severe irritation, redness, tearing and blurred vision.
Ingestion: May cause mouth, throat, and gastrointestinal tract irritation, nausea, vomiting and diarrhea. Aspiration of naphtha portion of this product into lungs can cause severe chemical
pneumonitis which may be fatal.

Chronic:
Prolonged or repeated skin contact with this product may result in irritation and dermatitis. IARC has classified extracts of steam and air refined bitumen as group 2b.

Carcinogenicity:

Hazardous ingredients: Listed as a carcinogen by:	**ACGIH**	**NTP**	**OSHA**
Extracts of steam and air refined bitumens (such as naphtha cutback asphalt)	no	no	no
Mineral Spirits	no	no	no

Medical conditions aggravated by exposure: Persons with a history of chronic skin or respiratory disorders may be increased risk for worsening their conditions from exposure to this product.

SECTION VI - REACTIVITY DATA

Stability (conditions to avoid): Product is stable. Product is combustible. Keep away from heat open flame, and sources of sparking.
Incompatibility (materials to avoid): Avoid contact with strong oxidizers and water.
Hazardous decomposition of products: Carbon dioxide, carbon monoxide, sulfur oxides, hydrogen sulfide and various hydrocarbon fractions.
Hazardous polymerization: Will not occur.

SECTION VII - ENVIRONMENTAL PROTECTION

Action taken for spills (use appropriate safety equipment): Prevent material from entering sewers and waterways. Remove all sources of ignition (flames, hot surfaces, and electric, static, or frictional sparking sources). Ventilate area. Absorb with inert materials such as vermiculite or sand and dispose of solid waste.
Waste disposal method: Dispose of in accordance with federal, state and local regulations. This material is "RCRA" regulated hazard waste and must be disposed of in a permitted facility. Drums are hazardous waste if not emptied completely (less than 1" of residue).

SECTION VIII - EMERGENCY AND FIRST AID DATA

INHALATION: Move individual to fresh air immediately. If breathing is difficult or if irritation persists, administer oxygen. If not breathing, administer artificial respiration. Seek medical attention.
SKIN CONTACT: For contact with cold material clean exposed skin with waterless hand cleaner, then wash with soap, and water. Note: Skin contact with clothing saturated in mineral spirits can cause second degree burns. Contaminated clothing should removed immediately and excess material wiped from skin. Wash with mild soap and water. Seek medical attention if condition persists.
EYE CONTACT: Immediately flush eyes with running water for at least 15 minutes. Seek medical attention immediately.
INGESTION: Do not induce vomiting. Prevent aspiration. Aspiration of material into lungs due to vomiting can cause severe chemical pneumonitis, which can be fatal. Seek immediate medical attention. Note to physician: Perform gastric lavage in accordance with procedures for ingestion of petroleum products.

SECTION IX - EMPLOYEE PROTECTION

Ventilation: Outdoor use - ensure adequate ventilation and avoid fumes by working upwind. Indoor use - insure adequate building ventilation and local exhaust.

Respiratory protection: If irritation occurs, or if the PELs, TLVs or NIOSH - RELs are exceeded, use a NIOSH/MSHA approved air purifying respirator with organic vapor cartridges or canisters and a dust/mist prefilter. In situations where the concentration exceeds the PEL or TLV, supplied air respirators or self contained breathing apparatus are required. Always use respiratory protection in accordance with your company's respiratory protection program and OSHA regulations under 29 cfr 1910.134.

Eye protection: Wear chemical safety goggles or a face shield when material is in liquid form.

Protective clothing: Wear long sleeve shirt and long pants. Leather or lined neoprene coated gloves should be used when there could be direct contact. Sunscreens may decrease potential for skin discoloration with chronic exposure.

Work/hygienic practices: Handle in accordance with good industrial hygiene and safety practices. These practices include avoiding any unnecessary exposure and removal of the material from the skin, eyes, and clothing. Wash hands and arms frequently. Shower after exposure. Wash work clothes when soiled. Safety showers and eye wash stations should be available.

SECTION X - STORAGE PRECAUTIONS

Precautions to be taken in handling and storage: Material is combustible. Vapors of mineral spirits are heavier than air and may travel along the ground or be moved by ventilation to locations distant from the point of material handling. To prevent ignition, avoid smoking, keep away from heat, open flames, and sources of static or electrical sparking. Use explosion proof motors and equipment. Tank trucks or other containers should be grounded and/or bonded when material is transferred.

SECTION XI - ADDITIONAL INFORMATION

NCPA - HMIS RATING

HEALTH (acute):	2
FLAMMABILITY:	2
REACTIVITY:	0
PERSONAL PROTECTION:	*

* Personal protective equipment requirements must be supplied by the user depending on use conditions.

While information and recommendations set forth are believed to be accurate. It is the users responsibility to determine the suitability of material for a specific purpose and adopt necessary safety precautions. We make no warranty as to the results obtained and disclaim all liability from reliance.

Attachment B – Polyurethane Product Data Sheet

AVANTI
Stop leaks. Stabilize soil.
Control groundwater. Permanently.

TECHNICAL DATA SHEET

AV-202® MULTIGROUT

HYDROPHILIC POLYURETHANE FOAM

DESCRIPTION
AV-202 Multigrout is a single component, moisture activated MDI/TDI blended polyurethane injection resin. Designed for sealing active water leaks in large cracks or joints in concrete structures, it can absorb up to 12 times its volume in water creating a tough, impermeable foam or gel with superb adhesive qualities. Certified for use in potable water.

APPLICATION
- Large cracks or joints in concrete, or used in conjunction with **AV-215** Resin Rod™ or **AV-219** Fibrotite™ (oakum) systems
- Designed for applications where high volume water flow is an active or potential problem and a high viscosity chemistry is required
- Used successfully in manhole sealing and pipe penetrations
- Excellent choice for moving cracks and joints

FEATURES AND BENEFITS
- ANSI/NSF 61 Drinking Water Systems Component – UL and WQA Certified
- 100% solids
- Expands 400% – 600%
- Solvent-free and non-corrosive
- Forms a resilient, flexible foam with superb adhesive properties
- Can accept up to 12X its volume in water
- May be used in underwater applications

GROUTING TECHNIQUES
- Expanded Gasket Placement Technique (EGP)
- Variable Pressure Application Technique (V-PAT) – Crack Injection

HOW IT WORKS
AV-202 can be applied via two techniques: EGP or V-PAT. The resin reacts to moisture to form a resilient, flexible seal accomplished by three mechanisms: the resin seeks out water in the space and *adheres* to the surface, then begins to expand forming a tight *compressive* seal, while the network of compressed grout material within all the cracks forms a *mechanical* lock.

RATIOS
Preferred ratio is 1:1 (water to resin), however no pre-mixing is required. Pumped as a single component and is effective at ratios up to 12:1 with water.

PACKAGING
Product packaged by weight based on specific gravity.

Drum	Net Wt. 484 lbs. (220 kg)
Pail	Net Wt. 44 lbs. (20 kg)
Gallon	Net Wt. 8 lbs. (3.6 kg)
Cartridge	10.114 fl. oz. / Volume ~ 300 ml.

SHIPPING
- Motor class 55
- Non-hazardous
- Air freight available

CLEANING PRODUCTS
- **AV-208** Technical Grade Acetone™ (CAS# 67-64-1) – removes moisture from equipment (see Performance section).
- **AV-284** Pump Wash™ (Proprietary Blend) – removes uncured resin from pump hose
- **AV-222** Cleaner™ (Proprietary Blend) – removes cured resin from equipment

PROPERTIES*

UNCURED	
Appearance:	Brown resin
Viscosity:	3,200 – 6,000 cP @ 77°F (25°C)
Flash Point:	253.4°F (123°C)
Specific Gravity:	1.090 @ 72°F (22°C) ± 3%
Density:	9.09 lbs. per gallon ± 3% (1.090 kg/L ± 3%)
CURED	
Appearance:	Milky colored flexible foam
Tensile Strength:	TBD
Elongation:	TBD

*Laboratory Results

PERFORMANCE
Flush equipment with **AV-208** before and after use to remove moisture and clean equipment. For best results, use between 60°F – 90°F (16°C – 32°C). Performance will be influenced by site conditions. If site temperatures are low, use a heat source to warm to ~72°F (22°C) and apply. Do not use open flame as a heat source.

At temperatures of 45°F (7°C), the viscosity of the product can significantly increase, making the miscibility with the reaction water more difficult.

STORAGE
Store in temperatures within or near 45°F – 95°F (7°C – 35°C) in a dry atmosphere. Keep container tightly closed when not in use. Packaged under dry nitrogen to keep moisture out and extend shelf life.
Note: storage of opened/partial containers at the lower range of the recommended storage temperature is not advised. The moisture in the air of the head space above a partial container might condensate and causes the grout to premature gel in the container.

SAFETY
Always use OSHA-approved personal protective equipment (PPE). Refer to the SDS for complete safety precautions. The SDS is available by request or via download at avantigrout.com.

NOTICE
The data, information and statements contained herein are believed to be reliable, but are not construed as a warranty or representation for which Avanti International assumes any legal responsibility. Since field conditions vary widely, users must undertake sufficient verification and testing to determine the suitability of any product or process mentioned in this or any other written material from Avanti for their own particular use. NO WARRANTY OF SUITABILITY OR FITNESS FOR A PARTICULAR PURPOSE IS MADE. In no case shall Avanti International be liable for consequential, special, or indirect damages resulting from the use or handling of this product.

AV-202 Multigrout is tested and certified by WQA against NSF/ANSI 61 Drinking Water System Components

Attachment C – Acrylamide Product Data Sheet

AVANTI
Stop leaks. Stabilize soil.
Control groundwater. Permanently.

TECHNICAL DATA SHEET

AV-100® CHEMICAL GROUT

GRANULES / LIQUID CHEMICALLY REACTIVE GEL

DESCRIPTION

AV-100 Chemical Grout is an ultra-low viscosity chemically reactive gel available as either granules or liquid. Having the same viscosity as water, **AV-100** can permeate anywhere water can travel and cures within a controllable time frame anywhere from 5 seconds to ±10 hours. Once it cures, it creates an effective, long-lasting water barrier while providing superb soil stabilization.

APPLICATION

- Stops water infiltration into manholes, sanitary and storm sewer mainlines, joints, laterals, tunnels, mines, and various other geotechnical applications and underground structures by stabilizing external substrate
- Ground modification/slope stability for prevention of landslides, erosion, or any place where site conditions or project requirements dictate modification of the existing soil properties

FEATURES AND BENEFITS

- Thinnest product on the market
- Can be injected through remote packer equipment
- Controllable reaction times from seconds to hours
- Will not undergo syneresis
- Half-life of 362 years for 20% grout concentration, as determined by U.S. Dept. of Energy
- No suspended solids
- Higher strength compared to acrylates
- Greater longevity compared to silicates
- Available in granular or liquid form

GROUTING TECHNIQUES

- Tube-a-Manchette (TAM) Grouting
- Probe Grouting
- Curtain Grouting
- Remote Packer

HOW IT WORKS

AV-100 is injected using a stainless steel, dual-component pump from two containers (see mix procedure). Injecting a 1:1 ratio into the soil or external substrate will produce a strong, impermeable gel obtained via a copolymerization reaction. Additives are available to modify the reactions and cured gel characteristics.

OPTIONAL ADDITIVES

- **AV-257** Icoset™ – increases strength (add to grout tank)
- **KFe** (Potassium Ferricyanide) – extends gel time (add to grout tank)
- **AV-105** Gel Guard™ – reduces freezing point (add equal amounts to both tanks)
- **Dyes** – used extensively for tracking grout flow

PACKAGING

	Net Wt.	Volume
Bag (Granules)	30 lbs. (13.6 kg) 50lbs. (22.6 kg)	—
Tote (Liquid)	2300 lbs. (1,043 kg)	258 – 265 gal. (976 – 1,003 L)
Drum (Liquid)	130 lbs. (58.9 kg)	14.6 – 15 gal. (55.2 – 56.7 L)

SHIPPING

- Motor class 77.5
- Hazard class 6.1
- Motor freight available
- Air freight available

PROPERTIES*

UNCURED (solid)	
Appearance:	White granules
Specific Gravity:	1.122 @ 68°F (20°C) ±3%
Bulk Density:	71.79 lbs./ft^3 ± 3% (1150 kg/m^3 ± 3%)
Toxicological:	See SDS
UNCURED (liquid)	
Appearance:	Clear water-white liquid
Viscosity:	1 – 2 cP @ 72°F (22°C) in solution
Specific Gravity:	1.03 @ 77°F (25°C) ± 3%
Density:	8.66 lbs./gal ± 3% (1.038 kg/L ± 3%)
Toxicological:	See SDS
CURED	
Appearance:	Clear gel mass/translucent
Hydraulic Conductivity:	< 10^{-8} m/s
Toxicity:	Non-toxic

*Laboratory Results

MIX PROCEDURE (See Mixing Instructions)

Tank A: Add 10 gallons (37.8 L) of water, add one 50 lb. bag (granules) or one liquid drum of **AV-100** to solution, add 0.5 gallons (1.9 L) of **AV-101®** Catalyst T+ and fill with water up to 30 gallons. Tank B: Add 10 gallons (37.8 L) of water, add 5 lbs. (2.27 kg) of **AV-102®** Catalyst AP, and then bring to 30 gallons with water. Makes a 60 gallon (227 L) batch. Note: Ingredients are only compatible with stainless steel or plastic.

PERFORMANCE

Performance will be influenced by site conditions. If site temperatures are low, heat the product to recommended operating temperatures of 60°F – 100°F (16°C – 38°C). Decreasing pH may extend cure time. High minerals/metals content may adversely affect gel time. Refer to **AV-100** Technical Manual for complete product information.

STORAGE

Store in temperatures within or near 45°F – 95°F (7°C – 35°C) in a dry atmosphere. Keep out of direct sunlight.

SAFETY

Use of **AV-100** is authorized by Avanti International only after completion of the required Safe Operating Practices Program (SOPP). Always use OSHA-approved personal protective equipment (PPE). Refer to the SDS for complete safety precautions. The SDS, mixing instructions, and Technical Manual are available by request or via download at avantigrout.com.

NOTICE

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Attachment D – QC Forms

Engineering & Construction Innovations, Inc.

DRILLING LOG

Project: _____
Date: _____
Start Time: _____
End Time: _____
Weather: _____
Ambient Temperature: _____

Hole Diameter: _____
Depth: _____
Driller: _____

Joint ID:	

Hole ID	Duration of drilling	Relocation Needed?	Comments
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			
K			
L			
M			
N			
O			
P			
Q			

Check:

1. Location per plan
2. Mark if relocation was needed due to interference with reinforcement
3. Mark if water was returning
4. Observation of material / Additional comments

Engineering and Construction Innovations, Inc.
7002 6th Street North □ Oakdale, Minnesota □ 55128
Phone: (651) 298-9111 □ Fax (651)298-9113

Engineering & Construction Innovations, Inc.

GROUTING SYSTEM TEST

Project: _____
Date: _____
Weather: _____
Ambient Temperature: _____

Hole Diameter: _____
Operator: _____

Joint ID:	

PUMPING RATE TEST

Component A: _____
Component B: _____
Pumping Start Time: _____
Pumping End Time: _____
Volume of Part A: _____
Volume of Part B: _____
Ratio: _____

Notes:

Check:
1. Check tolerance less than 20%
2. Mark if viscosity adjustment of parts was needed. Record all test / re-test.

GEL TIME TEST

Component A: _____
Component B: _____
Mixing Start Time: _____
Mixing End Time: _____
Gel time: _____

Notes:

Check:
1. Check that gel time is between 30 seconds and 3 minutes
2. Mark if viscosity adjustment of parts was needed. Record all test / re-test.

Engineering and Construction Innovations, Inc.
7002 6th Street North □ Oakdale, Minnesota □ 55128
Phone: (651) 298-9111 □ Fax (651)298-9113

Engineering & Construction Innovations, Inc.

GROUTING LOG

Project: _____
Date: _____
Weather: _____
Operator: _____

Component A: _____
Component B: _____
Component C: _____

Joint ID:

Hole ID	Water test		Grout volume	Comments
	Pressure	Time		
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				

	Water test	Mixing	Grout
Start Time:			
End Time:			

Ambient Temperature:	
Part A Temperature:	
Part B Temperature:	
Pumping rate:	1/4 gal/min

Check: _____

1. Mark if any water/grout leakage was observed in the oakum/asphalt plug c the water test / injection
2. Mark if any hole is watertight
3. Observation of material / Additional comments

Engineering and Construction Innovations, Inc.
7002 6th Street North □ Oakdale, Minnesota □ 55128
Phone: (651) 298-9111 □ Fax (651)298-9113

Engineering & Construction Innovations, Inc.

RE-DRILLING LOG

Project: _____
Date: _____
Start Time: _____
End Time: _____
Weather: _____
Ambient Temperature: _____

Hole Diameter: _____
Driller: _____

Joint ID:	

Hole ID	Depth of drilling	Comments
A		
B		
C		
D		
E		
F		
G		
H		
I		
J		
K		
L		
M		
N		
O		
P		
Q		

Static Cone Penetrometer Test

Location: Hole A
Soil resistance at 6": _____ psi
Soil resistance at 12": _____ psi
Soil resistance at 18": _____ psi
Comments:

Check:

1. Pressurized water flush the holes
2. Mark if any water leakge was observed in the oakum/asphalt plug during the flushing
3. Observation of material / Additional comments

Engineering and Construction Innovations, Inc.
7002 6th Street North □ Oakdale, Minnesota □ 55128
Phone: (651) 298-9111 □ Fax (651)298-9113

Engineering & Construction Innovations, Inc.

Quality Control Logs

Project: WIDOT Raymond Rd

Date _____

Shift _____

Material _____

Time mixing: _____

Time sample: _____

Outside Temperature: _____ ° F

Mixing Water Temperature: _____ ° F

Grout Temperature: _____ ° F

Viscosity		sec
Density		lb/ft^3
Spread		in
Cubes Cast		# (How Many)
		Time

NOTES:

_____

ECI Representative

Engineering & Construction Innovations, Inc.

Quality Control Logs - Bleeding Test

Project:

Location: Date _____

Grout: Time start mixing: _____. Time finish: _____

Wheater: Time sampling: _____.

TARGET:

Temperature ambient start: _____

Temperature ambient finish: _____

Temperature grout start: _____

Temperature grout finish: _____

Time	Volume grout (ml)	Volume water (ml)	**Time**	Volume grout (ml)	Volume water (ml)

Final Bleeding:	

$$Final\ bleeding, \% = \frac{V_w}{V_1} \times 100$$

NOTES:

_____

ECI Representative

Engineering & Construction Innovations, Inc.

Step by Step - Bleeding Test

Struments

Glass graduate, 1000 ml reading 10 ml
Glass graduate, 25 ml reading 1 ml
Thermometer

Steps

1. Take 1500 ml of representative grout sample
2. Record the grout and ambient temperature before start
3. Record time of start mixing, sampling and testing
4. Introduce grout in 1000 ml cylinder until volume is 800 ml +- 10ml
5. Record volume and time
6. Place cylinder on stady table and cover
7. Take record of upper surface of grout and bleed water every 15 min for 60 min and hourly until two successive reading shows no expansion/bleeding
8. At end, decant water in 25 ml cylinder and record volume
9. Record temperature of grout after test

Engineering & Construction Innovations, Inc.

Quality Control Logs - Especific Gravity

Project:
Location: Date _____
Wheater:

	Joint ID
W/C ratio	
Bags of Microfine	
Gallons of water	
Time Start mix	
Temp Amb (F)	
Temp Grout (F)	
Time Start Sample	
Specific Gravity ( )	
Time Finish	

NOTES:

_____
ECI Representative



Engineering & Construction Innovations, Inc.

Step by Step - Specific Gravity

Struments

Mud Balance +-0.01g/ml
Thermometer

Steps

1. Calibrate the mud balance with water (1.00 g/ml at 21 C/70 F). If it is not adjust balancing screw
2. Mud balance set on flat surface
3. Record time and temperature of start mixing, sampling and testing
4. Fill the balance cup to the lid with the grout
5. Put the cap on the filled sample and rotate the cap (check no free space and sealed)
6. Cover the cap hole with the finger and clean it
7. Place the beam on the support and balance it using the bubble
8. Record the Specific Gravity

Engineering & Construction Innovations, Inc.

Quality Control Logs - Viscosity

Project:
Location: Date
Wheater:

	Joint ID
TARGET VISCOSITY TIME	
W/C ratio	
Bags of Cement (94 lb)	
Gallons of water	
HRWRA (oz)	
Time Start mix	
Temp Amb (F)	
Temp Grout (F)	
Time Start Sample	
Viscosity Time (sec)	

NOTES:

ECI Representative

Engineering & Construction Innovations, Inc.

Step by Step - Viscosity

Struments

Marsh Funnel
Graduated Cup - 1000 ml
Stopwatch
Thermometer

Steps

1. Check calibration of Marsh Funnel with water (946 ml at 21 C/70 F in 26 sec+-0.5 sec)
2. Cover the funnel hole with a finger and pour grout throught the screen until reach bottom of screen
3. Remove finger and start stopwatch at same time
4. Measured time to fill 946 ml (1 qt mark)
5. Record temperature of grout

Engineering & Construction Innovations, Inc.

Cementicious Grout Log

Project :	WIDOT Raymond Rd	Date:	
		Shift:	
Start Time:		End Time:		Pipe Number	

ID	Depth (Rod to 38")	Planned Grout (gal)	Totalizer Start (gal)	Totalizer End (gal)	Actual Grout (gal)	Other Details
1	34"	2				
1	30"	2				
1	26"	2				
1	23"	2				
1	20"	2				
1	17"	2				
1	14"	2				
2	34"	2				
2	30"	2				
2	26"	2				
2	23"	2				
2	20"	2				
2	17"	2				
2	14"	2				
3	34"	2				
3	30"	2				
3	26"	2				
3	23"	2				
3	20"	2				
3	17"	2				
3	14"	2				
4	34"	2				
4	30"	2				
4	26"	2				
4	23"	2				
4	20"	2				
4	17"	2				
4	14"	2				

ID	Depth (Rod to 50")	Anticipated Grout (gal)	Totalizer Start (gal)	Totalizer End (gal)	Actual Grout (gal)	Other Details
5	46"	2				
5	42"	2				
5	38"	2				
5	25"	2				
5	32"	2				
5	29"	2				
5	26"	2				
5	23"	2				
5	20"	2				
5	17"	2				
5	14"	2				
6	46"	2				
6	42"	2				
6	38"	2				
6	25"	2				
6	32"	2				
6	29"	2				
6	26"	2				
6	23"	2				
6	20"	2				
6	17"	2				
6	14"	2				
7	46"	2				
7	42"	2				
7	38"	2				
7	25"	2				
7	32"	2				
7	29"	2				
7	26"	2				
7	23"	2				
7	20"	2				
7	17"	2				
7	14"	2				
8	46"	2				
8	42"	2				
8	38"	2				
8	25"	2				
8	32"	2				
8	29"	2				
8	26"	2				
8	23"	2				
8	20"	2				
8	17"	2				
8	14"	2				

Attachment E – TEA Accelerator Product Data Sheet

AVANTI
Stop leaks. Stabilize soil.
Control groundwater. Permanently.

TECHNICAL DATA SHEET

AV-101® CATALYST T+

TRIETHANOLAMINE (TEA) / ACTIVATOR

DESCRIPTION

AV-101 Catalyst T+ (often referred to as CAT-T) is a colorless liquid which is used as an activator for reaction of **AV-100®** Chemical Grout, **AV-180®** Duriflex, **AV-150™** Acrylate Gel and **AV-160™** SuperGel. The special blend of ingredients in **AV-101** reduces its freezing point to -3°F (-16°C) and enhances the final gel.

USED WITH

- **AV-100** Chemical Grout
- **AV-118** Duriflex
- **AV-150** Acrylate Gel
- **AV-160** SuperGel

PACKAGING

Product packaged by weight:

	Net Wt.
Pail	45 lbs. (20.4 kg)
Drum	496 lbs. (225 kg)

SHIPPING

- Motor Class 60
- Non-Hazardous
- Air freight available

CLEANING PRODUCTS

Use water with light detergent.

STORAGE

Store in temperatures within or near 45°F – 95°F (7°C – 35°C) in a dry atmosphere. Keep away from oxidizers. Keep out of direct sunlight.

PROPERTIES*

Appearance:	Clear liquid
Dynamic Viscosity:	50 cP @ 77°F (25°C)
pH:	10.5-11.5 (14.9% solution)
Boiling Point:	212-608°F (100-320°C)
Freezing Point:	-3°F (-16°C)
Flash Point:	199.9-354°F (93.3-179°C)
Vapor Pressure:	0.02 mmHg @ 68°F (20°C)
Specific Gravity:	1.115 @ 68°F (20°C)
Vapor Density:	2.4
Solubility in water:	100% @ 68°F (20°C)

*Laboratory Results

MIX PROCEDURE

If mixing with **AV-100** or **AV-118**, add ½ gallon (standard mix) to the grout-side tank. When adding additional **AV-101** to Tank A, an equal amount of **AV-102®** Catalyst AP or **AV-103®** Catalyst SP should be added to Tank B. See complete mixing instructions at avantigrout.com.

SAFETY

Always use OSHA-approved personal protective equipment (PPE). Refer to the SDS for complete safety precautions. The SDS is available by request or via download at avantigrout.com.

NOTICE

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Attachment F – Ammonium Persulfate Product Data Sheet

AVANTI
Stop leaks. Stabilize soil.
Control groundwater. Permanently.

TECHNICAL DATA SHEET

AV-102® CATALYST AP

AMMONIUM PERSULFATE / INITIATOR

DESCRIPTION

AV-102 Catalyst AP (often referred to as AP) is a white crystalline solid used as the initiator for the radical polymerization reaction of acrylic and acrylate monomers. Ammonium persulfate is a powder that is a required grout component for **AV-100®** Chemical Grout or **AV-118®** Duriflex and can be increased from 5 lbs. (1% by total mix weight of 500 lbs) to a maximum of 15 lbs. (3% by total mix weight of 500 lbs). When used with **AV-150** Acrylate Gel™ or **AV-160** Supergel™, the amount of **AV-102** is from 10 lbs. to a maximum of 30 lbs. (6% by weight). **AV-102** is a strong oxidizing material which decomposes over time.

USED WITH

- **AV-100** Chemical Grout
- **AV-118** Duriflex
- **AV-150** Acrylate Gel
- **AV-160** Supergel
-

PACKAGING

Product packaged by weight based on specific gravity.

	Net Wt.
Pail	50 lbs. (22.6 kg)
Drum	220 lbs. (99.7 kg)

SHIPPING

- Motor Class 65
- Hazard Class 5.1
- Air freight available

CLEANING PRODUCTS

Use water with light detergent.

PROPERTIES*

Appearance:	White crystals
Viscosity:	1-2 cP in solution
pH:	4 – 6 (1% solution)
Boiling Point:	Decomposes > 212°F (100°C)
Melting Point:	Decomposes > 212°F (100°C)
Flash Point:	Non-flammable
Specific Gravity (water=1)	1.98
Solubility:	85% by weight @ 77°F (25°C)

*Laboratory Results

MIX PROCEDURE FOR STANDARD MIX

When mixing with **AV-100** (Tank A), add 5 lbs. of **AV-102** to Tank B. When adding additional **AV-101** to Tank A, an equal amount of **AV-102** should be added to Tank B. See complete mixing instructions at avantigrout.com.

IMPORTANT: **AV-102** dissolved in water loses its effectiveness rapidly at elevated temperatures.

STORAGE

Store in temperatures within or near 45°F – 95°F (7°C – 35°C) in a dry atmosphere and keep the lid closed. Elevated temperatures and moisture will degrade AP. Keep away from reducing agents like **AV-101**.

SAFETY

Always use OSHA-approved personal protective equipment (PPE). Refer to the SDS for complete safety precautions. The SDS is available by request or via download at avantigrout.com.

NOTICE

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Attachment G – High strength mortar Product Data Sheet

BASF
The Chemical Company

MasterEmaco® S 488 (formerly known as Emaco S88C T)

Dual shrinkage compensated, trowelable fibre reinforced thixotropic repair mortar

DESCRIPTION

MasterEmaco S 488 trowelable mortar is a dual shrinkage compensated, thixotropic high strength formulation for structural concrete repairs.

MasterEmaco S 488 is suitable for placing in thicknesses of 12mm to 50 mm both vertically and overhead.

MasterEmaco S 488 provides a durable, strong structural repair fully compatible with host concrete.

RECOMMENDED USES

MasterEmaco S488 is the ideal material for vertical or horizontal structural repairs where the thickness of repair is more than 12mm and use of hand or machine applied structural repair systems is required. Typical applications are:

- Extensive repairs to beams, columns and other structural elements.
- Repair of structural members subjected to repetitive loading.
- Repairs to piers, navigation locks, dams seawalls and other marine structures
- Repairs to bridges, tunnels, garages, silos etc

FEATURES AND BENEFITS

- **Dual shrinkage compensated** - Volume stable in wet and hardened state reducing cracking tendency
- **One component, factory made only addition of water** - Uniform predictable performance even in remote situations
- **No bonding agent required** - Simple installation
- **Impermeable to aggressive elements** - Long life repairs
- **Sprayable** - Able to repair complex profiles easily with minimal rebound
- **Fast and easy placing** - Reduced time for repairs

PROPERTIES

Appearance	Grey powder
Water powder ratio	0.14
Density	Approx. 2300 kg/m3
Application temperature	
Substrate material	+5 to +40°C +5 to +30°C
Mixing water per 25kg bag	Approx. 3.25 – 3.75 litres
Compressive strength (ASTM C109 7cm cube)	20 MPa 1 Day
	50 MPa 3 Days
	60 MPa 7 Days
	70 MPa 28 Days
Flexural Strength (ASTM C348)	>9 MPa @ 28 days
Tensile Strength (ASTM C496)	>4 MPa @ 28 days
Resistivity approx.	12500Ωcm
Water penetration	< 5mm
Coefficient of Oxygen diffusion	2.58×10^{-8}

APPLICATION

Surface preparation

All loose traces of concrete or mortar, dust, grease oil, etc. must be removed. Damaged or contaminated concrete shall be removed to obtain a keyed aggregate exposed surface. Non-impact/ vibrating cleaning methods, e.g. grit or high pressure water blasting are recommended. Cut the edges of the repair vertically to a minimum depth of 5 mm. Clean all exposed reinforcement to a minimum grade of Sa 2 according to ISO 8501-1 / ISO 2944-4. Ensure back of reinforcing bar is also clean.

Where reinforcing bars are corroded, cut back the concrete to at least 20mm behind the reinforcing bars. Grit blast around the reinforcing bars to remove corrosion products and coat with **MasterEmaco P 130** to give corrosion protection.. Replace the affected part of rebar if the diameter after grit blasting is found reduced by more than 20% of the original diameter on the advice of the structural engineer responsible for the works.

Mixing

Only full bags are mixed. Damaged or opened bags should not be used. Mix **MasterEmaco S 488** in a forced action pan mixer, or with a helical paddle attached to a low speed (300-600rpm) mixer for 3 minutes until a lump free, thixotropic

MASTER® BUILDERS SOLUTIONS

BASF
The Chemical Company

MasterEmaco® S 488 (formerly known as Emaco S88C T)

consistency is achieved. Only use clean water. Mixing water needed: 3.25 to 3.75 litres per 25kg bag. Allow the mortar to rest for 2 - 3 minutes and then remix briefly before applying. If the temperature is more than 30^0C then use chilled water for the mixing water.

Priming Concrete

No special primer is required. To obtain extra strong bonding, the damp substrate can be primed with a slurry brush coat of **MasterEmaco S 488 (**2 parts powder to 1 part water).

Mortar application

The minimum temperatures must be maintained during application and for at least 24 hours thereafter for optimum curing of the product.

The prepared substrate should be pre-soaked, preferably for 24 hours, but at least 2 hours before applying **MasterEmaco S 488** The surface must be saturated surface dry, but without standing water. **MasterEmaco S 488** can be spray or hand applied. Apply mixed product directly to the prepared damp substrate, or wet in wet onto the primed surface. Spraying the material with the necessary pressure will ensure good adhesion of the material.

A thin scrape coat or contact layer before building up to the required thickness, wet on wet, will improve adhesion especially in case of hand application. Apply to the desired layer thickness of 12 mm to max 50 mm and level using a screeding bar, trowel or wooden board. Can be applied in thicker layers in smaller patches or where additional reinforcement is present. Smoothing with a trowel or finishing by float or sponge can be done as soon as the mortar has begun to stiffen.

Protective coatings

Subsequent coatings of **MasterProtect** anti-carbonation barriers or silane impregnations should be applied as recommend on the individual datasheets.

CURING

MasterEmaco S 488 should be cured with **MasterKure 181** or clear polythene sheeting over wet hessian.

ESTIMATING DATA

Each bag of **MasterEmaco S 488** when mixed with 3.5L of water yields 12.4L.

PACKAGING

MasterEmaco S 488 is available in 25kg bags.

SHELF LIFE

MasterEmaco S 488 has a shelf life of 6 months. Store out of direct sunlight, clear of the ground on pallets protected from rainfall.

PRECAUTIONS

For the full health and safety hazard information and how to safely handle and use this product, please make sure that you obtain a copy of the BASF Material Safety Data Sheet (MSDS) from our office or our website.

MasterEmacoS488/01/0313

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Attachment H – Crystalline waterproofing Product Data Sheet

XYPEX® CONCENTRATE

CEMENTITIOUS CRYSTALLINE

Concrete Waterproofing

Description

Xypex is a unique chemical treatment for the waterproofing, protection and repair of concrete. XYPEX CONCENTRATE consists of Portland cement, finely graded sand and active proprietary chemicals; it is applied as a cementitious slurry to the pre-saturated surface of existing above and below-grade concrete structures. The active chemicals diffuse into the substrate and react with moisture and the constituents of hardened concrete to cause a catalytic reaction. This reaction generates a non-soluble crystalline formation throughout the pores and capillary tracts of the concrete, as well as cracks, permanently sealing the concrete and preventing the penetration of water and other liquids from any direction, even under high hydrostatic pressure. Xypex Concentrate is also mixed in a Dry-Pac form for sealing strips at construction joints, or for the repairing of leaking cracks, faulty construction joints and other defects.

Recommended for:

- Reservoirs
- Water and Wastewater Treatment Plants and Sewage Systems
- Underground Structures and Vaults
- Secondary Containment Structures
- Foundations
- Bridges
- Conduits and Culverts
- Retaining Walls
- Tunnels and Subway Systems
- Swimming Pools
- Parking Structures
- Roof Decks

Advantages

- Resists extreme hydrostatic pressure
- Becomes an integral part of the substrate
- Can self-heal static hairline cracks up to 0.4 mm
- Can be applied to the positive or the negative side of the concrete surface
- Allows concrete to breathe
- Highly resistant to aggressive chemicals
- Non-toxic / no VOCs
- Does not require a dry surface
- Cannot puncture, tear or come apart at the seams
- No costly surface priming or leveling prior to application
- Does not require sealing, lapping and finishing of seams at corners, edges or between membranes
- Does not require protection during backfilling or during placement of steel, wire mesh or other materials
- Less costly to apply than most other methods
- Not subject to deterioration
- Permanent
- Available in white for enhanced illumination

Packaging

Xypex Concentrate is packaged in various sizes. Contact your local Xypex distributor or representative for details.

Storage

Xypex products must be stored dry at a minimum temperature of 7ºC. Shelf life is one year when stored under proper conditions.

Coverage

For normal surface conditions, the coverage rate for each Xypex coat is 0.65 - 0.8 kg/m^2.

Test Data

PERMEABILITY

U.S. Army Corps of Engineers (USACE) CRD C48, "Permeability of Concrete", Pacific Testing Labs, Seattle, USA

Two in. (51 mm) thick, 2000 psi (13.8 MPa) Xypex-treated concrete samples were pressure tested up to a 405 ft. (124 m) water head (175 psi/1.2 MPa), the limit of the testing apparatus. While untreated samples showed marked leakage, the Xypex-treated samples (as a result of the crystallization process) became totally sealed and exhibited no measurable leakage.

DIN 1048 (equivalent to EN 12390-8), "Water Impermeability of Concrete", Bautest – Corporation for Research & Testing of Building Materials, Augsburg, Germany

Twenty cm thick Xypex-treated concrete samples were pressure tested up to 7 bars (230 ft./70 m water head) for 24 hours to determine water impermeability. While the reference specimens measured water penetration up to a depth of 92 mm, Xypex-treated samples measured water penetration of zero to an average of 4 mm.

EN 12390-8, "Depth of Water Penetration on Samples Treated with Concentrate Coating", OL-123, Czech Technical University, Prague, Czech Republic

Three replicate 150 mm concrete cubes from four different mix designs (strength classes) were coated with Xypex Concentrate at a thickness of 0.8 mm to 1 mm. Controls for each of the different mix designs were also cast for comparison purposes. All samples were exposed to 0.5 MPa (73 psi) of water pressure for 72 hours from the opposite side of the treated surface. Specimens from each set were split transversely from the treated surface at 28 and 91 days to measure depth of water penetration from the exposed surface. After 28 days, the Xypex coating reduced the depth of water penetration by 90 to 94% compared to the control mixes for the four mix types. At 91 days all Xypex-treated samples measured <1 mm of water penetration.

DEPTH OF PENETRATION

"Measurement of Mass Concrete Humidity", Czech Technical University, (CVUT) Faculty of Civil Engineering, Prague, Czech Republic

A coating of Xypex Concentrate was applied to one face of a 300 mm x 300 mm x 220 mm set of concrete blocks;

two replicate sets of blocks were left untreated. Water filled containers were tightly sealed onto the opposite face of the treated blocks and one set of the untreated blocks while the third untreated block set was kept in the laboratory as a control. Humidity probes were installed in 6 mm diameter holes that were drilled to within 30 - 40 mm of the water exposed surface. Mass humidity was recorded at intervals of 28, 45, 90, 125 and 132 days. Final results showed that the Xypex-treated specimens had an average humidity reading of 4.6%, the untreated sample measured 7.9% and the control block with no water exposure was 4.4%, essentially equivalent to the Xypex specimens' results. The Xypex reactive chemicals had diffused at least 190 mm in 132 days.

"An Enhancement in the Nature of Concrete with a Multiplicative Cement Crystal-Type Concrete Material", Central Research Laboratory of Nikki Shoji in association with Hosei University, Japan



A 60 cm x 70 cm x 40 cm concrete block was cast and a Concentrate coating was applied to the surface and cured. The block was left outdoors for approximately 1 year. Subsequently, a 40 cm (15.75 in.) long cylinder was then cored perpendicular to the Xypex treatment and cut into 18 slices of equal length. SEM photographs utilizing a 1000x magnification were taken of slices from various depths from the treated surface to determine the extent of crystalline growth. While the crystalline structure was most dense in specimens located closest to the treated surface, there was evidence of the crystalline structure at 30 cm (12 inches) from the treated surface.

SEALING CRACKS

ASTM C856 "Standard Practice for Petrographic Examination of Hardened Concrete", Setsco Services Pte, Ltd., Singapore

A coat of Xypex Concentrate was applied to a slab that had developed numerous hairline cracks. To determine the crack sealing ability of the Xypex treatment, cores were extracted from a slab at 3, 10, 14 and 20 days following application. Thin sections were taken from each core in order to examine hairline cracks utilizing a polarizing and fluorescent microscope (PFM). In each case, there was evidence of the Xypex crystalline structure in the cracks to a depth of about 20 mm. Photographs taken this depth at 100x magnification showed the Xypex crystalline structure had reduced the width of the cracks dramatically.

TENSILE BOND STRENGTH

EN 1542 "Products and Systems for the Protection and Repair of Concrete Structures – Test Methods – Measurement by Pull-off", Trow Associates Inc., Burnaby, B.C., Canada

Two coats of Xypex Concentrate were applied at 0.8 kg per m^2 with a total cured thickness of 0.9 mm to a standard concrete substrate meeting EN 1766 MC (0,40). The coating was applied and cured to the manufacturer's technical specifications and tested at 30 days age for bond strength. The average tensile bond strength of five replicates was 1.23 MPa.

CHEMICAL RESISTANCE

ASTM C 267, "Chemical Resistance to Mortars", Pacific Testing Labs, Seattle, USA

Xypex-treated cylinders and untreated cylinders were exposed to hydrochloric acid, caustic soda, toluene, mineral oil, ethelyne glycol, pool chlorine, brake fluid and other chemicals. Results indicated that chemical exposure did not have any detrimental effects on the Xypex coating. Tests following chemical exposure measured an average 17% higher compressive strength in the Xypex-treated specimens over the untreated control samples.

IWATE University Technical Report, "Resistance to Acid Attack", Tokyo, Japan



Before Immersion *After 5 Weeks* *After 10 Weeks*

Xypex-treated mortar and untreated mortar were measured for acid resistance after exposure to a 5% H_2SO_4 solution for 100 days. Xypex suppressed concrete erosion to 1/8 of the reference samples.

ASTM C876 "Influence of Xypex Coating System on Residual Service Life of Concrete Structures" Durability Assessment Section, Xypex Australia

A bridge pier exposed to seawater in a tidal splash zone for over 40 years experienced different types of deterioration mechanisms including surface abrasion (skin loss), cracking, and corrosion of steel reinforcement. Corrosion monitoring was conducted before and six months after application of Xypex Concentrate. This non-destructive testing (NDT) included a measurement of the corrosion rate, corrosion potential, and concrete resistivity. Results indicated a reduction of corrosion rate and corrosion potential up to 50% and 40% respectively, and significant enhancement of the concrete resistivity.

RILEM CPC-18 "Carbonation Resistance of Samples Treated with a Xypex Concentrate Coating", Construction and Maintenance Technology Research Center (CONTEC), Sirindhorn International Institute of Technology (SIIT) – Thammasat University, Bangkok, Thailand

Control and Xypex Concentrate coated samples were carbonated in an accelerated carbonation chamber. The average depths of carbonation were measured at 28, 56, 77 and 91 days. The depth of carbonation of these Xypex Concentrate coated samples was reduced by 35 - 40% compared to the controls. Following initial carbonation, one set of samples was coated with Xypex Concentrate to model old concrete already damaged by carbonation. For these specimens, testing indicated that carbonation was arrested and in one specimen reduced.

FREEZE/THAW DURABILITY

ASTM C 672, "Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to De-Icing Chemicals", Twin City Testing Lab, St. Paul, USA

Xypex-treated samples restricted chloride ion concentration to below the level necessary to promote electrolytic corrosion

of reinforcing steel. Visual examination of untreated panels after 50 freeze/thaw cycles showed a marked increase in surface deterioration compared to Xypex-treated samples.

POTABLE WATER EXPOSURE

AS/NZS 4020 "Products For Use In Contact With Drinking Water", Australian Water Quality Centre, Adelaide, South Australia

NSF 61, "Drinking Water System Component-Health Effects", NSF International, Ann Arbor, USA

Exposure testing of potable water in contact with Xypex-treated samples indicated no harmful effects.

RADIATION RESISTANCE

U.S.A. Standard No. N69, "Protective Coatings for the Nuclear Industry", Pacific Testing Labs, Seattle, USA

After exposure to 5.76 x 10^4 rads of gamma radiation, the Xypex treatment revealed no ill effects or damages.

Application Procedures

1. **SURFACE PREPARATION** Concrete surfaces to be treated must be clean and free of laitance, dirt, film, paint, coating or other foreign matter. Surfaces must also have an open capillary system to provide "tooth and suction" for the Xypex treatment. A CSP-3 per the International Concrete Repair Institute Guidelines and Surface Profile Chips is recommended. If surface is too smooth (e.g. where steel forms are used) or covered with excess form oil or other foreign matter, the concrete should be lightly sandblasted, waterblasted, or etched with muriatic (HCL) acid.

2. **STRUCTURAL REPAIRS – PRIOR TO COATING APPLICATION** For cracks larger than 0.4 mm or for actively leaking cracks the following repair procedures are recommended. Chip out cracks, faulty construction joints and other structural defects to a depth of 37 mm and a width of 25 mm. A "V" shaped slot is not acceptable. The slot may be saw cut instead of chipped but ensure that the slot is dovetailed or otherwise shaped such that there will be mechanical interlock of materials placed into the slot at a later stage. Clean and wet the slot and apply a brush coat of Xypex Concentrate as described in steps 5 & 6 and allow to dry for 10 minutes. Fill cavity by tightly compressing Dry-Pac into the groove with pneumatic packing tool or with hammer and wood block.

NOTE:

i. Areas of poor concrete consolidation that show evidence of leakage should also be repaired.

ii. Against a direct flow of water (leakage) or where there is excess moisture due to seepage, use Xypex Patch'n Plug, then Xypex Dry-Pac followed by a brush coat of Xypex Concentrate.

iii. For expansion joints or chronic moving cracks, flexible materials such as expansion joint sealants should be used.

iv. Prior to the installation, it is recommended that a test section be completed under anticipated ambient and project conditions to demonstrate appropriate bond strength.

3. **WETTING CONCRETE** Xypex requires a saturated surface dry (SSD) condition. Concrete surfaces must be thoroughly saturated with clean water prior to the application so as to aid the diffusion of the Xypex chemistry and to ensure growth of the crystalline formation deep within the pores of the concrete. Remove excess water before the application such that there is no glistening water on the surface. If concrete dries out before application, it must be re-wetted.

4. **MIXING FOR SLURRY COAT** Mix Xypex powder with clean water to a creamy consistency in the following proportions:

For Brush Application
0.65 - 0.8 kg/m^2
5 parts powder to 2 parts water

1.0 kg/m^2
3 parts powder to 1 part water

For Spray Application
0.65 - 0.8 kg/m^2
5 parts powder to 3 parts water
(ratio may vary with equipment type)

Do not mix more Xypex material than can be applied in 20 minutes. As the mixture thickens, stir briefly to ensure mixture remains fluid; but do not add water.

Mixing Dry-Pac
Using a trowel, mix 6 parts Xypex Concentrate powder by volume to 1 part clean water for 10 to 15 seconds. Lumps should be present in this mixture. Do not mix more than can be applied in 20 minutes.

5. **APPLYING XYPEX** Apply Xypex with a semi-stiff nylon bristle brush, push broom (for large horizontal surfaces) or specialized spray equipment. The coating must be uniformly applied and should be just under 1.25 mm. When a second coat (Xypex Concentrate or Xypex Modified) is required, it should be applied after the first coat has reached an initial set but while it is still "green" (less than 48 hours). Curing by misting the coating with water should be done between coats. Ensure first coat is in SSD condition before application of the second coat. The Xypex treatment must not be applied under rainy conditions or when ambient temperature is below 4ºC. Avoid application of the Xypex coating in hot and windy conditions as the coating may dry out prematurely. For recommended equipment, contact Xypex Australia or your nearest Xypex representative.

6. **CURING** Generally a misty fog spray of clean water is used for curing the Xypex treatment. Curing should begin as soon as the Xypex has set to the point where it will not be damaged by a fine spray of water. Under normal conditions, it is sufficient to spray Xypex-treated surfaces three times per day for two to three days. In hot or arid climates, spraying may be required more frequently. Wet burlap and some specialty curing blankets are also effective for curing. During the curing period, the coating must be protected from rainfall, frost, wind, the puddling of water and temperatures below 2ºC for a period of not less than 48 hours after application. If plastic sheeting is used as protection, it must be raised off the Xypex to allow the coating to breathe. Xypex Gamma Cure may be used in lieu of water curing for certain applications (consult with Xypex Australia or your nearest Xypex representative).

NOTE:
i. For concrete structures that hold liquids (e.g. reservoirs, swimming pools, tanks, etc.), Xypex should be cured for three days and allowed to set for 12 days (18 days for waste water or corrosive solutions) before filling the structure with liquid.

ii. For Xypex coated slabs that will be a wearing surface, an application of Xypex Quickset after the coating has been cured and dried is recommended. Contact your local Xypex Technical Services Representative for assistance.

iii. If any other cementitious system is applied over the Xypex coating, it should be after the coating has completely set but while it is still green (12 to 48 hours); the 12 to 24 hour window is considered ideal. For installations onto a Xypex coating older than 48 hours contact your Xypex Technical Service Representative regarding surface preparation and application recommendations. Xypex Australia makes no representations or warranties regarding the compatibility of Xypex products with plasters, stuccos, tiles and other surface-applied materials. Prior to the installation, it is recommended that a test section be completed under anticipated ambient and project conditions to demonstrate appropriate bond strength.

Technical Services

For more instructions, alternative application methods, or information concerning the compatibility of the Xypex treatment with other products or technologies, contact the Technical Services Department of Xypex Australia or your local Xypex Technical Services Representative.

Safe Handling Information

Xypex is alkaline. As a cementitious powder or mixture, Xypex may cause significant skin and eye irritation. Directions for treating these problems are clearly detailed on all Xypex pails and packaging. The Manufacturer also maintains comprehensive and up-to-date Safety Data Sheets on all its products. Each sheet contains health and safety information for the protection of workers and customers. The Manufacturer recommends you contact Xypex Australia or your local Xypex Technical Services Representative to obtain copies of Safety Data Sheets prior to product storage or use.

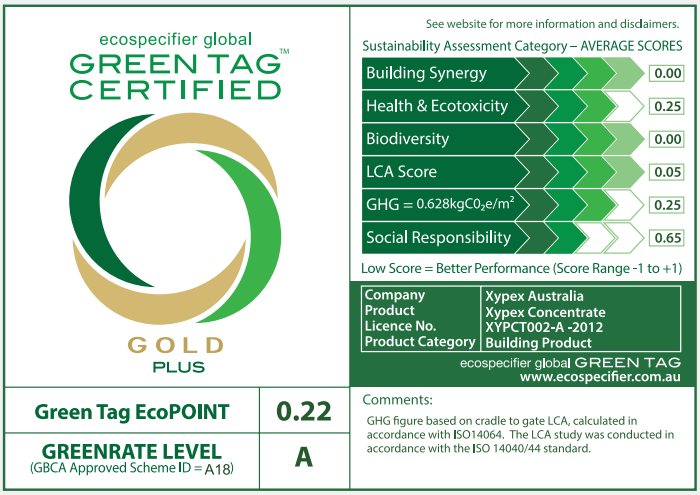
Warranty

Concrete Waterproofing Manufacturing Pty Ltd (trading as Xypex Australia) (the “Manufacturer”) warrants that the products manufactured by it shall be free from material defects and of a consistent quality. Should any of the products be proven defective, the liability of the Manufacturer shall be limited to replacement of the product ex-factory. The Manufacturer gives no warranty as to fitness of the products for any particular purpose. The user shall: determine the suitability of the product for its intended use; comply with the directions for use and safe handling information available from Xypex; where necessary, engage an experienced Xypex applicator; and assume all risks and liabilities in connection with the use of this product.

Sustainability

Both GreenTag LCARate and GreenRate are recognised third party certification schemes for Green Star® in Australia and NZ and can certify in a single certificate all Materials Calculators, VOCs, Formaldehyde Reduction, Best Practice PVC and Post Consumer Recycled Content credits. GreenTag is a unique Australian Competition and Consumer Commission (ACCC) approved National Certification Mark and is also registered as a Certification Mark in the EU and UK and is also the Preferred Certifier for the EarthCheck Eco-hospitality certification program.





XYPEX®
Manufactured under license by Concrete Waterproofing Manufacturing Pty. Ltd.
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Attachment I - Microfine cementitious material Product Data Sheet

AVANTI
Stop leaks. Stabilize soil.
Control groundwater. Permanently.

TECHNICAL DATA SHEET

ULTRAFINE SD™

CEMENTITIOUS GROUT

DESCRIPTION
Ultrafine cementitious grouts are composed of a finely ground mixture of Portland cement, pumice pozzolan, and dispersant. Avanti's Ultrafine grout has an average particle size of 3 microns, in stark contrast to typical particle sizes of 60 to 70 microns in conventional cements. **Ultrafine SD** grout is formulated with a naphthalene sulfonate based superplasticizer for a fool proof system with minimal bleed and high compressive strengths for use in both rock fracture and soil stabilization applications.

APPLICATION
- Stabilizing weak soils
- Sealing seepage in mines, dams, and tunnels
- Low permeability grout curtaining
- Hazardous waste containment
- Oil well squeeze cementing

FEATURES AND BENEFITS
- Smaller particle size will penetrate smaller fractures and finer soils
- Ready to use – no additives required
- Stable North American source of supply
- Composed of non-hazardous materials
- Lower permeability, means reduced hydraulic conductivity and extended longevity when compared to ordinary Portland cement.

GROUTING TECHNIQUES
- Probe Grouting
- Curtain Grouting

HOW IT WORKS
The chemical synergy created by combining finely ground OPC with highly reactive natural pumice pozzolan and naphthalene sulfonate-based superplasticizer allows for a confident design with minimal bleed and high compressive strengths.

OPTIONAL ADDITIVES
- Additional additives may be used based on contractor field tests and project parameters.

PACKAGING
- Standard packaging is in 44 lbs. (20 kg) bags or 2,000 lbs. (900 kg) Super Sacks.

SHIPPING
- Motor Class 55
- Non-Hazardous
- Air freight is NOT available

MIX PROCEDURE
These precise mixing instructions must be followed for best results:
1. Mixer should be a high-shear "colloidal" mixer.
2. Recommended Water/dry grout ratio is 0.8/1 by weight.
3. Add water to mixer and set unit on high speed.
4. Slowly add dry grout to mixer.
5. Mix at high speed for desired time limit.

IMPORTANT:
NEVER blend **USG Super** with **Ultrafine SD**. The two products are incompatible and will negatively affect the set time and strength of the cement.

CLEANING PRODUCTS
Use water with light detergent.

PROPERTIES – DRY

Superplasticizer**:	0.9% by weight	
Color:	Cement gray	Visual
Particle Size:	90% < 8 microns, average 3 microns	SediGraph 5100
Surface Area:	15,110 cm^2/gram	ASTM C-204
Loose Unit Weight:	0.497 grams/cc	
Specific Gravity:	2.70 grams/cm^3	Accupyc 1330
Dry Weight/Wet Volume:	1.01 kg/liter	

PROPERTIES – WET

Water/Dry Grout**:	0.8/1 by weight	
Specific Gravity*:	1.54 grams/cc	API RP 13B-1
Initial Viscosity*:	33 ~ 37 seconds	API RP 13B-1
Internal Cohesion*:	1.22 Pascals	Lombardi Plate
Initial Gelation*:	2.5 ~ 5.0 hours	Wally Baker Shear Vane
Final Gelation*:	4.5 ~ 7.0 hours	Wally Baker Shear Vane
Initial Vicat Needle Set*:	9.33 hours	ASTM C-191
Final Vicat Needle Set*:	9.83 hours	ASTM C-191
Period of Workability*:	2.5 ~ 5.0 hours	
Shrinkage*:	-0.0260%	ASTM C-490, C-596, C-157
Bleeding*:	0.50%	ASTM C-940
Hydrational Heat*:	31°C	Adiabatic Chamber
Pressure Filtration*:	0.100 ~ 0.103 $min^{-1/2}$	API Filter Press
Sulfate Resistant:	Resistant to attack	Type V Cement
Permeability*:	1x10E^{-14} cm/sec	Custom Equipment of Atomic Energy of Canada

*Varies with water/cement ratio and superplasticizer content
**Recommended starting mix

PERFORMANCE
This grout is thixotropic which means it will become stiff if allowed to remain at rest. This is true of all ultrafine cement grouts. The material will re-liquefy when a pressure slightly in excess of the materials internal cohesion is applied. In practice, the grout is kept in motion through the use of a continuous loop grouting setup.

STORAGE
Store in sealed bags only. Partially used, open bags will take on ambient moisture. Product should be stored in a covered, dry area to avoid exposure to moisture. There are no specific ambient temperature restrictions for storage, however, sudden dramatic changes in temperature that may promote moisture condensation should be strictly avoided.

SAFETY
Always use OSHA-approved personal protective equipment (PPE). Refer to the SDS for complete safety precautions. The SDS is available by request or via download at avantigrout.com.

NOTICE
The data, information and statements contained herein are believed to be reliable, but are not construed as a warranty or representation for which Avanti International assumes any legal responsibility. Since field conditions vary widely, users must undertake sufficient verification and testing to determine the suitability of any product or process mentioned in this or any other written material from Avanti for their own particular use. NO WARRANTY OF SUITABILITY OR FITNESS FOR A PARTICULAR PURPOSE IS MADE. In no case shall Avanti International be liable for consequential, special, or indirect damages resulting from the use or handling of this product.

Attachment J - Acrylic Resin Product Data Sheet

AVANTI
Stop leaks. Stabilize soil.
Control groundwater. Permanently.

TECHNICAL DATA SHEET

AV-150 ACRYLATE GEL™

CHEMICALLY ACTIVATED GEL

DESCRIPTION

AV-150 Acrylate Gel is a non-toxic, ultra-low viscosity chemically activated gel. **AV-150** has the same viscosity as water which allows it to permeate anywhere water can travel and cures within a controllable time frame from 20 seconds to ±5 minutes. Once it cures, it creates an effective, long-lasting water barrier while providing superb soil stabilization.

APPLICATION

- Stops water infiltration into manholes, sanitary and storm sewer mainlines, joints, laterals, tunnels, mines, and various other geo-technical applications and underground structures by stabilizing external substrate.
- Ground modification/slope stability for prevention of landslides, erosion, or any place where site conditions or project requirements dictate modification of the existing soil properties.

FEATURES AND BENEFITS

- High solids content grout
- Can be injected through remote packer equipment
- Controllable reaction times from seconds to minutes
- Will not undergo syneresis
- No suspended solids
- Greater longevity compared to silicates

HOW IT WORKS

AV-150 is injected using a stainless steel, dual-component pump from two containers (see mix procedure). Injecting a 1:1 ratio into the soil or external substrate will produce a strong, impermeable gel obtained via a copolymerization reaction.

OPTIONAL ADDITIVES

- **AV-105** Gel Guard™ – reduces freezing point (add equal amounts to both tanks)
- **KFe** (Potassium Ferricyanide) – extends gel time (add to grout tank; KFe will precipitate out of solution in less than 1 hr, tank MUST be under continuous mixing or erratic gel times are expected)
- **Dyes** – used extensively for tracking grout flow

PACKAGING

Product packaged by weight based on specific gravity.

	Net Wt.
Tote	2,420 lbs. (1,098kg)
Drum	484 lbs. (220 kg)
Pail	44 lbs. (20 kg)

SHIPPING

- Motor Class 55
- Non-Hazardous
- Air freight available

PROPERTIES*

UNCURED

Appearance:	Clear Liquid
Viscosity:	15 – 20 cP @ 77°F (25°C) liquid resin
pH:	6.5-7.5
Flash Point:	223°F (106°C) CC
Specific Gravity:	~ 1.0735

CURED

Appearance:	White tinted gel mass
Toxicity:	Non-toxic
Elongation:	70%
Swelling:	25%

*Laboratory Results

TYPICAL MIX PROCEDURE

Comp A: Add 5% by weight (measured on the quantity of the **AV-150**) of **AV-101®** Catalyst T+ to the **AV-150** component.
Comp B: Add 5% by weight (measured on the quantity of the AV-150) of **AV-102®** Catalyst AP or **AV-103®** Catalyst SP, and complete with water to equal quantity of **AV-150**.

Pump at a 1:1 by volume
Note: Ingredients are only compatible with stainless steel or plastic.

PERFORMANCE

Performance will be influenced by site conditions. If site temperatures are low, heat the product to recommended operating temperatures of 40°F – 100°F (4°C – 38°C). Decreasing pH may extend cure time. High minerals/metals content may adversely affect gel time.

STORAGE

Store in temperatures within or near 45°F – 95°F (7°C – 35°C). Keep out of sunlight. **Caution**: keep each ingredient stored separately. **AV-101** will react violently when it comes in contact with **AV-102** Catalyst AP or **AV-103** Catalyst SP.

SAFETY

Always use OSHA-approved personal protective equipment (PPE). Refer to the SDS for complete safety precautions. The SDS, mixing instructions, and Technical Manual are available by request or via download at avantigrout.com.

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Attachment K - Epoxy Resin Product Data Sheet

AVANTI
Stop leaks. Stabilize soil.
Control groundwater. Permanently.

TECHNICAL DATA SHEET

AV-502-MV INJECTABLE BONDING EPOXY MV™

HIGH-STRENGTH INJECTION EPOXY RESIN

DESCRIPTION
AV-502-MV Injectable Bonding Epoxy MV is a medium viscosity, unique formula developed for structural concrete repair by crack injection, gravity feed or patching. It can be used as a liquid binder for sand, aggregate or any other mineral filler to patch or resurface damaged concrete slabs. This material may be used to repair masonry, wood, and other rigid construction materials. **AV-502-MV** is 100% solids, VOC free and Butyl Glycidyl Ether (BGE)* free.

AV-502-MV meets or exceeds requirements of ASTM C 881 or AASHTO M-235 (Types I and IV, Grade 2, Class C).

APPLICATION
- Binder for aggregates to patch or resurface damaged concrete slabs
- Repair of masonry, wood and concrete structures

FEATURES AND BENEFITS
- Non-shrink
- User friendly mix ratio of 2:1 by volume
- Butyl Glycidyl Ether (BGE)*free
- Long working time
- Medium viscosity
- Excellent adhesion
- ASTM C 881 compliant

INJECTION TECHNIQUES
- Gravity feed
- Crack Injection with dual cartridges or two-component injection pump

HOW IT WORKS
AV-502-MV has a user friendly mixing ratio (2:1 by volume) which allows its application by dual cartridges or automatic injection equipment. Surface seal with Avanti's non-corrosive **AV-522 Crack Sealing Paste** for manual or automatic injection.

PACKAGING
3-Gallon Kit

Resin	2.0 gallons in 3.5 gallon pail
Hardener	1.0 gallon

SHIPPING
- Motor Class 55
- Resin: Not Regulated
- Hardener: Not Regulated
- Air freight available

CLEANING PRODUCTS
- **AV-544** Epoxy Tool Cleaner™ (Proprietary Blend) – removes uncured and cured resin from equipment
- **AV-208** Technical Grade Acetone™ (CAS# 67-64-1) – removes uncured resin from equipment
- **AV-222** Cleaner™ (Proprietary Blend) – removes cured resin from equipment

STORAGE
Store between 60°F – 80°F (15°C – 27°C) in a dry atmosphere. Keep containers closed. Temperatures below 60°F (16°C) may cause partial crystallization of the resin. If crystallization has occurred, heat the resin in its original container placing it into another container with hot water.

SAFETY
Always use OSHA-approved personal protective equipment (PPE). Refer to the SDS for complete safety precautions. The SDS is available by request or via download at avantigrout.com.

*BGE (Butyl Glycidyl Ether). The EPA (SARA Title III, section 312) lists BGE as "Toxic" (per ANSI Z129.1) by skin absorption and an immediate health hazard.

PROPERTIES*
AV-502-MV UNCURED Resin and Hardener

Appearance:	Clear
Mixed Viscosity:	3,000 cP @ 68°F (20°C)
Flash Point:	Resin: >200°F (>93°C) Hardener: >212 °F (>100 °C) CC
Solids:	100%
Specific Gravity (mixed):	1.05 @ 72°F (22°C)
Density:	8.79 lbs./gal 1,050 kg/m^3
Working Time (100 g)	80 minutes
Gel Time (100 g)	130 minutes

AV-502-MV CURED

Tensile Strength:	55.2 MPa (8,000 psi) – ASTM D638
Elongation @ break:	10.0% - ASTM D638
Compressive Strength:	96.5 MPa (14,000 psi) – ASTM D695
Adhesion to concrete	5.5 MPa (>800 psi) 100% failure in concrete
Hardness Shore D	80 – ASTM D2240

*Laboratory Results

SURFACE PREPARATION
To achieve excellent adhesion, the substrate should be free of all loose and foreign material and should be clean. Oils, grease, waxes or other contaminates must be removed prior to application. Be sure the crack is open where ports are placed. Set ports with Avanti's non-corrosive **AV-522** Crack Sealing Paste.

MIXING PROCEDURE
For best performance, the ideal application temperature range is between 70-80°F (21-32°C) but can be extended between 60-100°F (16-38°C). Mix 2 parts A (resin) to 1 part B (hardener) for 3 minutes using a Jiffy Mixer and a slow speed drill. Mix at slow speed (less than 500 rpm) to avoid air entrainment. DO NOT mix more material than can be used within the stated working time. REMEMBER - you will have less working time at higher temperatures.

AV-502-MV and **AV-522** Crack Sealing Paste may be removed from tools with Avanti's **AV-544** Epoxy Tool Cleaner or warm soapy water before they are fully cured.

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Attachment L - EPDM Rubber Gland and Stainless Steel Compression bands Product Data Sheet

HydraTech HydraTite®

Internal Joint Sealing System

Issue 10.14

PRODUCT DESCRIPTION

- HydraTite Internal Joint Seal is a mechanical, trenchless remediation for repair of pipe joints.
- The HydraTite system consists of a proprietary rubber seal which spans the joint and is held in place by stainless steel retaining bands in either side of the joint.
- These retaining bands are expanded and locked in place using a wedge lock design which forms an air tight clamp around the joint eliminating all infiltration and exfiltration.
- Each HydraTite seal is designed and custom made for each application to ensure complete compliance with project specifications.
- The HydraTite System is a recognized method of joint repair by AWWA manual M28.

APPLICATIONS	MARKETS SERVED
Joint Repair	Potable Water
Expansion Joint Remediation	Natural Gas
End Seal for CIPP	Sanitary Sewers
Manhole Chimney Seal	Storm Sewers
Seal Off Abandon Laterals	Cooling Water
Flexible Pipe Liner	Service Water
	Circ. Water

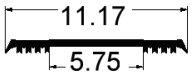
Advantages

- Mechanical Trenchless Remediation
- Maintenance free
- Turnkey installation
- Low profile ensures minimal flow loss
- Patented interlocking design for lining long length of pipe
- Rapid installation and return to service ideal for immediate or emergency situations
- Seal Flexibility accommodates shifting, vibration and thermal expansion and contraction
- Non-corrosive components
- Design Flexibility provides an ideal remediation for multiple applications
- Minimal surface prep required
- Test Valve ensures every installation has a pressure tested fit
- NSF/ANSI 61 Approved for potable water 18”-218” diameter pipe
- Installed by fully trained application specialists
- Full contract support services available

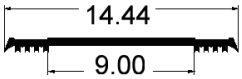
DESIGN FLEXIBILITY

WIDTHS • The HydraTite seal is available in three widths:

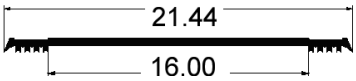
STANDARD



EXTRA-WIDE



DOUBLE-WIDE



RUBBER • The Seal is supplied in either EPDM or Nitrile. The EPDM is used in applications for potable water, waste water, and sea/brackish water. The Nitrile seal provides superior resistance to gas, oil, and petroleum based reagents making it ideal for natural gas applications.

STEEL • The retaining bands are manufactured to project specifications using either carbon steel, 304 stainless steel, 316L stainless steel or AL-6XN.

RETAINING BANDS • The retaining bands can be supplied as one piece or multiple pieces to accommodate entry restrictions. Systems can also be designed that incorporated extra retaining bands to provide additional support

DIAMETERS • The HydraTite System can accommodate pipe diameters from 18 inches to 218 inches.

BACKING PLATE • A stainless steel backing plate can be incorporated behind the seal to provide support when spanning voids in the pipe wall. This design is utilized in the remediation of expansion joints, sealing off abandoned laterals, and the repair of deteriorated joints.

INTERLOCKING • The patented sleeving design allows for the interlocking of multiple seals. This design provides a means by which to line long lengths of pipe to remediate axial as well as circumferential defects.

HydraTech’s engineering staff designs each HydraTite System to ensure conformance for all project specifications. Each HydraTite seal is then custom-made per the design specification. The HydraTite System offers the design flexibility needed to ensure the ideal system is utilized.

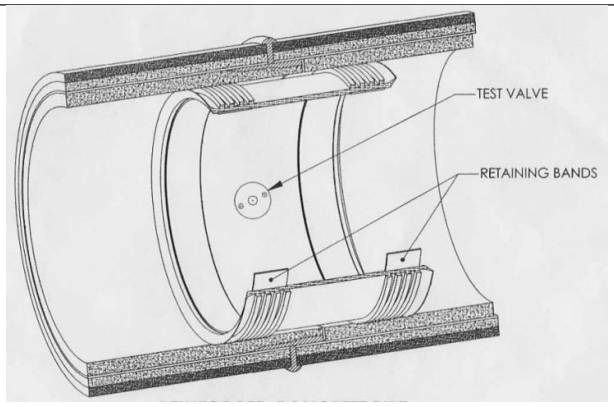
HydraTech Engineered Products LLC
10448 Chester Road, Cincinnati, OH 45215 Phone (513) 827-9169 Fax (513) 827-9171
www.hydratechllc.com

ANSI Accredited Program
PRODUCT CERTIFICATION
NSF / ANSI 61

HydraTech HydraTite®

Internal Joint Sealing System

Issue 10.14



SYSTEM PROPERTIES

Operating Pressure	300psi
Max Operating Temp	250˚F
Head Pressure	150 feet

EPDM

Durometer Shore A	ASTM D2240	65+/-5
Tensile Strength (min)	ASTM D412	1,450psi
% Elongation (min)	ASTM D412	350
Suffix A13 ASTM D573 Heat aged 70hrs @ 70˚C		
Durometer Shore A		+/-15
Tensile Change		+/-30
Elongation Change (max)		-50
Suffix B13 ASTM D395B Compression set 22hrs @ 70˚C		
Permanent set (%)		25 max
Suffix C12 ASTM D1171		
Ozone Resistance (%)		85 min

STAINLESS STEEL

Properties	304	316L	AL-6XN
UNS Designation	S30400	S31603	N08367
Tensile Strength(min)	75,000psi	70,000psi	100,000psi
Yield Strength (min)	30,000psi	25,000psi	45,000psi
Elongation (min)	40%	40%	30%
Brinell Hardness (max)	201	217	233
Weld Wire TS	80,000psi	70,000psi	110,000psi

The HydraTech HydraTite System is a performance driven product that provides a mechanical, trenchless remediation for the interior of pipe. The HydraTite system is backed by our engineering staff that services each installation with assessments, solutions, and technical support. The HydraTite system offers a proven, efficient, cost effective, long term solution to the most challenging demands of the industry.

INSTALLATION PROCEDURE



Prep Joint



Position Seal



Install Rubber Seal



Install Retaining Bands



Expand Bands with Expander



Insert Wedges



Pressure Test Seal



Check for Leaks

HydraTech Engineered Products LLC
10448 Chester Road, Cincinnati, OH 45215 Phone (513) 827-9169 Fax (513) 827-9171
www.hydratechllc.com

FORM 1

HydraTite® Internal Joint Seal **Installation Verification Form**

Project No.:
Project I.D.:
Seal Number:

Item To Be Verified	*Pipeline Verifier Signature*	*Date*
Sealing surface of pipe has been smoothed and is free of debris.		
HydraTite® Internal Joint Seal is located so lip seals do not rest on the pipe joint.		
Retaining Bands Inspect retaining bands / hardware.		
Hydraulic Pressure Record hydraulic expander pressure.		
Interference Wedge Record time after completion of seal installation with all wedges in place.		
Verify that a minimum of 30 minutes has elapsed before conducting pressure test.		
Pressure Test Seal is pressurized to 5 PSIG (±1 PSIG) during leak test of seal surface.		
No leakage as indicated by bubbling is observed at seal surface.		
Seal is depressurized and test port threaded plug has been installed and sealed.		
All installation hardware, testing band and pressure gauges have been removed.		

Date **Pipeline Verifier's Signature**

DO NOT COPY – DO NOT DUPLICATE

HydraTech ENGINEERED PRODUCTS

INTERNAL HydraTite JOINT SEAL

Installation Procedure OPS-01

1.0 OBJECTIVE

1.1 The objective of this procedure is to describe the proper techniques for the installation of the HydraTite Internal Joint Seal System to ensure the highest quality is achieved by:

1.1.1 Proper preparation of substrate.

1.1.2 Proper training and qualification of installation personnel.

1.1.3 Proper installation of the HydraTite Internal Joint Seal System components.

1.1.4 Completion of installation and test reports.

2.0 REFERENCES

2.1 HydraTite Drawing Seal and Band Assembly Profile

2.2 HydraTite Drawing Seal Assembly Profile

3.0 PREREQUISITES

(Note: The following prerequisites do not have to be performed in the sequence listed.)

3.1 This procedure is intended to be used by personnel who have been trained in the proper installation techniques of the HydraTite Seal System. It is not intended to be used by personnel who have not received this training.

3.2 Inspect and certify that all materials are available and ensure correct labeling.

3.3 For pressurized piping system repairs, this procedure shall be performed while the piping has been removed from service and an adequate safety-tagging boundary has been established and verified. For repairs in active gravity flow systems, this procedure shall only be performed if a safe environment can be established and in accordance with applicable local and national safety standard and procedures. Reference Section 4.0.

3.4 All necessary tools and equipment are available.

3.5 All required pressure gauges have been verified as calibrated and operational.

3.6 All permits have been processed which cover the scope of work to be performed inside the pipe.

3.7 Unless otherwise agreed upon, all lines have been dewatered, by-passed, and are at atmospheric pressure.

3.8 Access to the lines has been provided.

3.9 All consumables (i.e. hydraulic oil, lubricants, thread sealers, markers, etc) have been approved by the owner.

3.10 Verify the hydraulic expander has been provided for use in expanding the retaining bands.

3.11 Continuous forced air ventilation has been established and is sufficient to maintain the confined space safe for entry.

3.12 Training has been completed for personnel involved in installation activities.

4.0 PRECAUTIONS

4.1 If any unanticipated or unexpected alarm, noise, vibration, odor or excess leakage is observed, personnel shall immediately exit and remain outside the confined space until the condition is identified and rectified.

4.2 Preparation should be made for emergency rescue situations. In the event of an emergency, under no circumstance should the attendant enter the confined space until help has arrived, and then only with the proper rescue equipment. Attendants participating in the rescue effort must have received specialized training in confined space rescue techniques. Rescues are to be accomplished using emergency rescue carts or trolleys with a lifeline attached. At no time should the hole man (safety person) exert any pulling force on the anatomy of the person being rescued. The main must always be cleaned to the point that transportation carts (emergency and work carts) can ride on their wheels without encumbrance due to obstructions or main debris.

5.0 PROCEDURE

5.1 Verify that all prerequisites are completed and precautions noted.

5.2 Perform an inspection of pipe interior. Review all seal installation locations, paying particular attention to those at elbows, to verify that the piping/fitting geometry will allow the installation of the HydraTite Seal System.

5.3 Remove all dirt, scale, and other debris from the pipe walls in areas where the seal is to be installed. These cleaning operations shall be accomplished by hand brushing and scraping, pneumatic wire brushes, and/or oil-free air jet.

5.4 Mark the location of one edge of the lip seal on the pipe ID to clearly define the seal installation position(s).

5.5 All high/low surface imperfections (i.e. dirt, scale, and other debris) running axially through or part way through the sealing surface must be removed prior to installation of the seal. Any joint gaps or deep imperfections must be properly filled with an approved joint filling material and rendered smooth.

5.6 Load or transport the components of HydraTite Seal System (rubber seal, associated bands and hardware) into the piping and position at the point of repair.

5.7 For multi-piece bands, pre-assemble the bands can be completed to facilitate installation.

5.8 Lubricate the rubber sealing surface (extruded rib area) with approved gasket lubricant (EaseOn™ Pipe Lubricant, or equivalent). This use of lubricant is to ensure even distribution of hydraulic loading of the seal during band expansion. NOTE: limit amount of lubricant used to prevent excess movement.

5.9 Position the rubber seal over the joint with the pressure test valve (if applicable) located at approximately either the 9 o'clock position or the 3 o'clock position. The seal must be positioned accurately on the joint area per the marking established in 5.4

5.10a For one-piece retaining bands, clips are furnished to align the ends of the retaining bands. Slide the clip over the one end of the retaining band and insert the mating end thru the clip to hold the retaining band to together.

5.10b For multi-piece bands, assemble the retaining band with the furnished bolts. Finger tighten the bolts. Do NOT tighten bolts at this point. Connection should allow for movement of the bands while expanding.

5.11 With the retaining bands fully collapsed (smallest assembled diameter), position the band over the extruded ribs of the seals (in one of the channeled grooves) of the rubber seal. If needed, the retaining band can be expanded by hand to create tension and allow band to remain in position.

5.12 Install the 2" x 6" metal radiused shims (underneath the retaining band (between retaining band and EPDM seal) in the wedge area(s). Each connection area on the multi piece bands should have a shim placed in the wedge zone.

5.13 For Multi-piece bands partially expand the band at one of the two expansion points and insert the appropriate sized wedge.

5.14 Position the seal expander in line with the retaining band while ensuring that the retaining band remains in the grove.

5.15 Expand the band using the hydraulic expander, holding pressure for at least two minutes.

5.16 For single and multi-piece bands (at the second expansion joint) expand the band to the recommended pressure (see Attachment C) .

5.17 Install a radiused locking piece (wedge) in the exposed gap between the expanded band ends. The wedge size shall be selected so as to provide an interference fit.

5.18 From the outside edge of the rubber seal, utilize a hammer to drive the wedge(s) fully into the slot-avoid damaging the seal body by utilizing the wedge tool.

5.19 Once wedges are installed, release the pressure from expansion tool and set aside.

5.20 Repeat installation steps for subsequent bands on the same seal.

5.21 When applicable, perform an air test on the seal sections after a minimum of 30 minutes has elapsed after final fitting of the seal to be tested.

5.21.1 Pressurize to 5 PSIG through the seal test valve. Apply an approved soap test solution to the seal ends and inspect for leakage.

5.21.2 If the pressure test indicated leakage, determine cause, and repeat air test. Follow 5.22 for replacement of wedge to obtain tighter seal.

NOTE: A pressure test will be negligible if there is a leak path within the pipe area (hole in the pipe) or joint being sealed. It is recommended to maintain a supply of 5 PSIG to the seal and apply an approved soap test solution to the seal ends and inspect for leakage around the end of the seal.

5.21 If a leak is observed during the leak test, re-expand the retaining band in question and replace wedge piece with larger size. Re-test per 5.21.

5.22 On multi-piece bands remove bolts one at a time, coat with LocTite™ 242 or an equivalent threadlocker (NSF61 approved when required) and tighten the bolts in accordance with good practice. For ¼-20 bolts a torque of 10 ft-lbs may be used.

5.23 Depressurize seal and isolate test port. Using an approved thread sealing compound, install the threaded countersunk hex head completion plug. Remove all installation hardware, test band, and pressure gauges from the pipe.

6.0 RESPONSIBILITIES

6.1 The Director of Operations is responsible to ensure that personnel have the experience and qualifications necessary to perform the tasks assigned.

6.2 Unless otherwise authorized and certified by HydraTech Engineered Products, Only HydraTech trained personnel (HydraTech Field Services) are approved to install HydraTite seals.

6.3 Training

6.3.1 It should be noted that HydraTech utilizes certified contractors to install the HydraTite Seal System. HydraTech can also provide training services for other installation contractors or client employees at the job site or at office locations in order to install the seals.

6.3.2 This training performed is valid for one year and can not be assigned to other contractor personnel.

6.3.3 At the completion of training the authorized HydraTite training supervisor or his designee may issue to the contractor a certificate of training completed for each individual.

6.3.4 One copy of the certificate will be maintained by HydraTech Engineered Products, LLC.

Attachment A
TRAINEE SIGN-OFF SHEET

HydraTite Qualified Installer

I acknowledge that I have been given a copy and trained on the HydraTite Installation Procedure.

_____

Company Name

_____

Employee Signature Date

_____

Qualified HydraTech Engineered Products Trainer Signature Date

Attachment B – HydraTite Equipment Checklist

- ☐ First aid Kit
- ☐ SCBA
- ☐ Hearing Protection
- ☐ Gloves
- ☐ Safety Shirts & Vests
- ☐ Dust/Nuisance Masks
- ☐ Air Mover
- ☐ Intruder & Winches
- ☐ Safety Harnesses
- ☐ Insect Spray
- ☐ Drinking Water & Cooler
- ☐ Trash Containers & Bags
- ☐ Hydraulic Expander, Pump & Fluid
- ☐ Hack Saw
- ☐ Wrenches (Adjustable, Pipe & Combo)
- ☐ Welder/Generator
- ☐ Screwdrivers (Phillips & Straight)
- ☐ 6" Scrapers
- ☐ Vise Grips
- ☐ Slag Hammer
- ☐ Dead Blow Hammer
- ☐ Grinders and Sanding Disks
- ☐ Water Pumps
- ☐ Air Compressor
- ☐ Zip Gun & Bits
- ☐ Marking Pens
- ☐ Duct Tape
- ☐ Rags
- ☐ 5 Gallon Mixing Buckets
- ☐ Punch Lock Clamps
- ☐ Strap Tape
- ☐ Marking Chalk
- ☐ Hose Clips
- ☐ Whip Hose
- ☐ Blower Hose
- ☐ Air Regulators
- ☐ Ball Valve
- ☐ Welding Hood & Gloves
- ☐ Allen Wrench Kit
- ☐ Hammer – 4 lb.
- ☐ Wedges & Shims
- ☐ Fire extinguisher
- ☐ Hard Hats
- ☐ Safety Glasses
- ☐ Air Monitor
- ☐ Eye Wash
- ☐ Traffic Cones
- ☐ Ladders
- ☐ Rope Wheel
- ☐ Rubber Boots
- ☐ Respirators
- ☐ Lights & Charger
- ☐ Knifes – Utility & Hawkbill
- ☐ Bug Sprayer
- ☐ Circumference Tape
- ☐ Socket Wrenches
- ☐ Tape Measures (16' & 25')
- ☐ Hole Punches
- ☐ Coal Shovels
- ☐ Wire Brushes
- ☐ Metal Files
- ☐ Extension Cords & Pigtails
- ☐ Chop Saw & Blades
- ☐ Drill Motor & Bits
- ☐ Welder & Weld Rod
- ☐ Hose Rubbers
- ☐ Ease-On Pipe Lube
- ☐ Non-Toxic Thread Dope
- ☐ WD-40
- ☐ Epoxy
- ☐ Mixing Paddles
- ☐ Paint Brushes
- ☐ Wisk Brooms
- ☐ Mechanics Wire
- ☐ Test Hose & Brass Test Fitting
- ☐ Quick Connects
- ☐ Hydraulic Cement
- ☐ Liquid Gages
- ☐ Wedge Extractor & Wedge Tray
- ☐ Worm Clamps
- ☐ Workman & Cleaning Carts
- ☐ Band Bolts

Attachment C - Recommended Expander Pressure

		Recommended Band Thickness (inches)				
Size (inches)	**Max. Expander Pressure (psi)**	**AL6XN**	**304 Stainless Steel**	**316L Stainless Steel**	**A36 Carbon Steel**	**1020 Carbon Steel**
Standard Expander						
12	1100	1/8	1/8	1/8	1/8	1/8
12	1500	3/16	3/16	3/16	3/16	3/16
16	1500	1/8	1/8	1/8	1/8	1/8
16	2000	3/16	3/16	3/16	3/16	3/16
18	1500	1/8	1/8	1/8	1/8	1/8
18	2000	3/16	3/16	3/16	3/16	3/16
20	2500	3/16	3/16	3/16	3/16	3/16
20	3000	1/4	1/4	1/4	1/4	1/4
24	3200	3/16	3/16	3/16	3/16	3/16
24	3500	1/4	1/4	1/4	1/4	1/4
30	3200	3/16	3/16	3/16	3/16	3/16
30	3500	1/4	1/4	1/4	1/4	1/4
36	3500	3/16	3/16	3/16	3/16	3/16
36	3800	1/4	1/4	1/4	1/4	1/4
42	3500	3/16	3/16	3/16	3/16	3/16
42	3800	1/4	1/4	1/4	¼	1/4
48	3800	3/16	3/16	3/16	3/16	3/16
48	4000	1/4	1/4	1/4	1/4	1/4
54	4000	3/16	3/16	3/16	3/16	3/16
54	4300	1/4	1/4	1/4	1/4	
60	4400	1/4	1/4	1/4	1/4	
72	4500	1/4	1/4	1/4	1/4	
78	4500	1/4	1/4	1/4	1/4	
84	4600	1/4	1/4	1/4	1/4	
96	4600	1/4	1/4	1/4	1/4	
108	4800	1/4	1/4	1/4	1/4	
120	4800	3/8	3/8	3/8	3/8	
138	4800	3/8	3/8	3/8	3/8	
216	5000	3/8	3/8	3/8	3/8	

Material Yield Strength (psi)	45000	30000	25000	36000	63700
Band Width 2 inches					
Shims – 18 Gauge Material					

Step 9: Testing



Remove the small fitting located in the test fitting and insert threaded connector hose that is attached to air supply. Pressurize the back of the seal to 5 psi. The seal should expand outward or balloon. If there is a large opening in the joint it may not be possible to back pressure the joint. While the seal is pressurized use a solution of soapy water to spray around the edges of seal to detect any leakage. If leakage is detected repeat steps 1 thru 8, as necessary.

Step 10: Remove Test Equipment



Remove the test hose and replace the test valve fitting. The installation is complete.

January 13, 2020

Mr. Dan Weinkauf
Integrity Grading and Excavating, Inc.
605 Grossman Drive
Schofield, WI 54476

VIA E-Mail: dan@integrityge.com

RE: Raymond Road, Verona, Wisconsin – Culvert Pipe Restoration Proposal (Final Revision)

Dear Mr. Weinkauf:

Engineering & Construction Innovations (ECI) is pleased to submit this final revised proposal for the Raymond Road Culvert Pipe Restoration. We have based our proposal on information exchanged over the course of the last month and the plans and specifications developed by BDA Associates.

Scope of Work

ECI has developed our scope of work based on the following major activities:

Mobilization:

- Equipment and material
- Cofferdam and dewater discharge end of pipe
- Bypass internal flow
- Frost projection and heat
- Power and lighting
- Material storage, transport and protection
- Water usage
- Clean pipe (Once)
- Access to work

We will mobilize to the project site and set up to utilize the existing culvert apron as the major construction access to the work areas inside of the existing concrete pipe. The mouth of the existing culvert will be developed by adding some additional clean course aggregate fill to create a ramp down into the small basin and into the apron of the pipe. Crews will install and secure temporary utilities inside the pipe consisting of temporary electric power cords, Duraplus ABS compressed airline, PVC potable water line and a 6-inch PVC bypass pipe. All temporary utilities will be removed upon completion of the work.

Water control will be paramount during the work to maintain grouting quality and the project schedule. ECI plans on constructing a partial cofferdam/overflow weir in the invert of the upstream manhole to catch water inflows with electric submersible pump(s) connected to a 6-inch PVC bypass pipe to convey flows through the entire length of the project. A low-flow weir bypass pipe will be constructed in the CMU weir and an inflatable sewer ball will provide positive sealing when bypassing water. The sewer ball will be deflated and removed for any pump maintenance or if significant precipitation is to occur and more pipe capacity is needed. ECI has successfully used this system before on storm tunnel rehabilitation projects to handle dry weather and moderate wet weather flows. ECI will monitor weather forecasts and plan the work sequences accordingly should significant wet weather events occur during construction. All equipment and personnel will be evacuated from the tunnel and temporary utilities removed or secured should an event be eminent. We have included a preliminary drawing of the temporary upstream CMU bypass weir and a general arrangement of the utilities to be installed within the pipe to facilitate the repair work. Photos from past projects using similar stormwater bypass systems are also attached for further reference. All temporary measures will be completely removed upon completion of the work and any anchor holes patched with an approved mortar.

Temporary heating is planned for the work during the periods where the ambient underground temperature of the concrete pipe surface is less than 45 degrees. Heating will involve 1-3 surface mounted indirect-fired forced air units feeding ventilation trunk lines inserted into the upstream and intermediate manhole structures to achieve proper working conditions. Air bulkheads will be installed as needed at the outlet portal of the pipe as well as any intermediate manholes/pipes that contribute to heat loss underground to further regulate temperature and promote proper ventilation of the workspace in accordance with applicable OSHA standards for confined spaces.

ECI will be constructing temporary shelter(s) to properly receive and store the various grouts and specialty construction components necessary to complete the work. These temporary provisions will likely require heating to maintain products within the limits set by the manufacturers and the project specifications. We have significant experience working with all of the grouts required for the project and proper cold weather handling for quality results.

We anticipate maintaining a full-time top land crew consisting of a minimum of two personnel dedicated to receiving truck shipments and efficiently storing materials into the site erected shelters. In addition, this crew will be in constant communication with underground personnel via a radio repeater connected to an underground leaky wire system and supply any needed tools or materials below ground using existing manhole structures. This radio system allows the underground workers direct communication with the top-side team members to maintain productivity and safety throughout the project. The personnel above ground will be responsible for monitoring weather forecasts and current conditions working in conjunction with the project superintendent.

Potable water for the project will be obtained from an existing fire hydrant within the project area. ECI will request a meter from the local water authority and pay all water usage fees.

Scope:

A detailed bid schedule defining the scope of work is attached. A brief description of ECI's understanding of the scope and how the work will be accomplished is as follows.

Remedial grouting of the elliptical concrete pipe will start at the upstream box manhole structure and progress in a downstream manner. Each joint treatment will begin with necessary cleaning and preparation of the existing concrete surface prior to drilling and installing grout ports. Crews will locate the reinforcing wires in the pipes and use electric hammer drills to install seventeen (17) grout ports into each pipe joint per the BDA Drawings. A penetrometer test of the bedding soil will be conducted at each joint at the 6 o-clock position through a grout hole, as defined in the project plans, prior to commencing the grouting operation at the joint.

Water will be injected into the installed ports in a sequential manner to pre-wet the pipe joint and to identify any leaking areas. These locations will be packed with oakum and asphaltic coating to seal the joint prior to grout injection. Hydrophilic polyurethane grout will then be pumped into each port around the joint using the prescribed methods outlined in the project plans and specifications.

The next stage of grouting at each pipe joint starts by removing the grout port installed for the hydrophilic grout and re-drilling the hole to a point just outside the concrete pipe wall. All seventeen (17) grout holes will be re-drilled in this process, flushed with water and a new grout port installed. Plural component acrylamide grout will be pumped, statically mixed and injected into each of the ports. We have assumed each port will take three (3) gallons of the mixture. Ports will be removed once grouting is complete, the hole re-drilled and then patched with a non-shrink 6,000 PSI mortar. Crystalline waterproofing will be applied to the surface of the mortar patches.

Ultra-fine (UF) cement grouting of each pipe segment will be initiated once the hydrophilic and acrylamide joint treatments have been completed. Drilling of injection points will be in the pattern and prescribed depths as outlined in the plans and specifications. ECI has included drilling each of the holes full depth with a hammer drill bit to facilitate successful installation of injection needle piping. Strata-Tech QC4 Cam Wall Lock Ports will be installed into each of the drilled holes and tightened into place with a wrench. UF cement grout will be mixed using a colloidal mixer to the proportions outlined in the plans (W/C ratio = 0.76 (approximately)) from a plant set-up located above ground. Mixed grout will be transferred down the existing manholes and into the pipe via hoses and slick-line to a secondary agitating tank/progressive cavity pump set-up underground to facilitate precise and accurate placement. ECI has calculated the grout quantity based on the instructions outlined in the plans and defined in the bid schedule. Grouting work will progress from the upstream MH location to the downstream portal. Ports will be removed once grouting is complete, the hole re-drilled and then patched with a non-shrink 6,000 PSI mortar.

Two penetrometer tests of the bedding soil will be conducted in each pipe segment through a UF grout hole, as defined in the project plans, prior to commencing the UF grouting operation in each segment of culvert. A minimum of seven days after the culvert segment grouting is complete, two penetrometer tests of the bedding soil will be conducted in each pipe segment through new test holes drilled through the pipe, as defined in the project plans. The Engineer will use the pre-grout and post-grout test data to confirm bedding capacity improvements.

Crystalline waterproofing will be applied to existing cracks that meet the criteria outlined in the plans. These areas will be prepared by cleaning the concrete surface with a stiff bristle brush and compressed air flush. Waterproofing material will be placed with a brush in accordance with the manufacturer's application recommendations.
Crack injection will be in the areas identified in the plans and as marked in the field by the engineer. ECI will drill and install grout ports at a 45-degree angle and 5-inch spacings alternating sides along the length of the crack to be treated. Water will be injected into each port to verify the drill hole intersects the crack and to flush debris prior to grout injection. Polyacrylate grout will be mixed and injected into the ports at a rate of ¼ gallon per LF of crack. Ports will be removed once grouting is complete and patched with a non-shrink 6,000 PSI mortar.

Epoxy crack injection of larger cracks will be completed in the various areas outlined in the plans. ECI will use AV-522 to surface treat the crack area and secure the ports to the pipe. Once this material reaches its required set, the crack will be injected with AV-502. Ports will be removed after the injected epoxy has cured and the area restored as necessary.

ECI has not received pricing from a qualified subcontractor for installation of the thermoplastic sheet strip seals, therefore no pricing for the installation of the seals is being provided. ECI is providing pricing for the alternate HydraTite internal joint seals. ECI has experience installing the HydraTite seals for joint repair in irregular shaped combined sewers and will be self-performing the installation on this project.

ECI will repair the concrete pipe at 128 EA locations per the plans and specifications. Repairs will utilize dry-pack or troweled application methods to install the same 6,000 PSI repair mortar used to patch grout port holes.

Pricing and assumptions for the work are presented below:

- *Assumptions:*

  - All permits/easements/traffic control provided by others.
  - Work hours 7AM – 7PM, Monday through Saturday.
  - Heavy/Highway wage scale.
  - Winter conditions included.
  - ECI's standard insurance coverages are acceptable.
  - Payment/Performance bond is included.

➢ *Schedule:*

ECI estimates 18-20 weeks to complete the project working 6 days per week- 12 hours per day. We are open to discussing working 5 days per week – 24 hours per day to accelerate the work if desired by the client and after-hours city work permits can be made available.

➢ *Pricing:*

See attached bid schedule.

ECI appreciates the opportunity to provide this proposal and looks forward to working on this challenging project. If you have any questions regarding this proposal, please do not hesitate to call me at (651) 298-9111 or (320) 267-8134.

Sincerely,
Engineering & Construction Innovations, Inc.

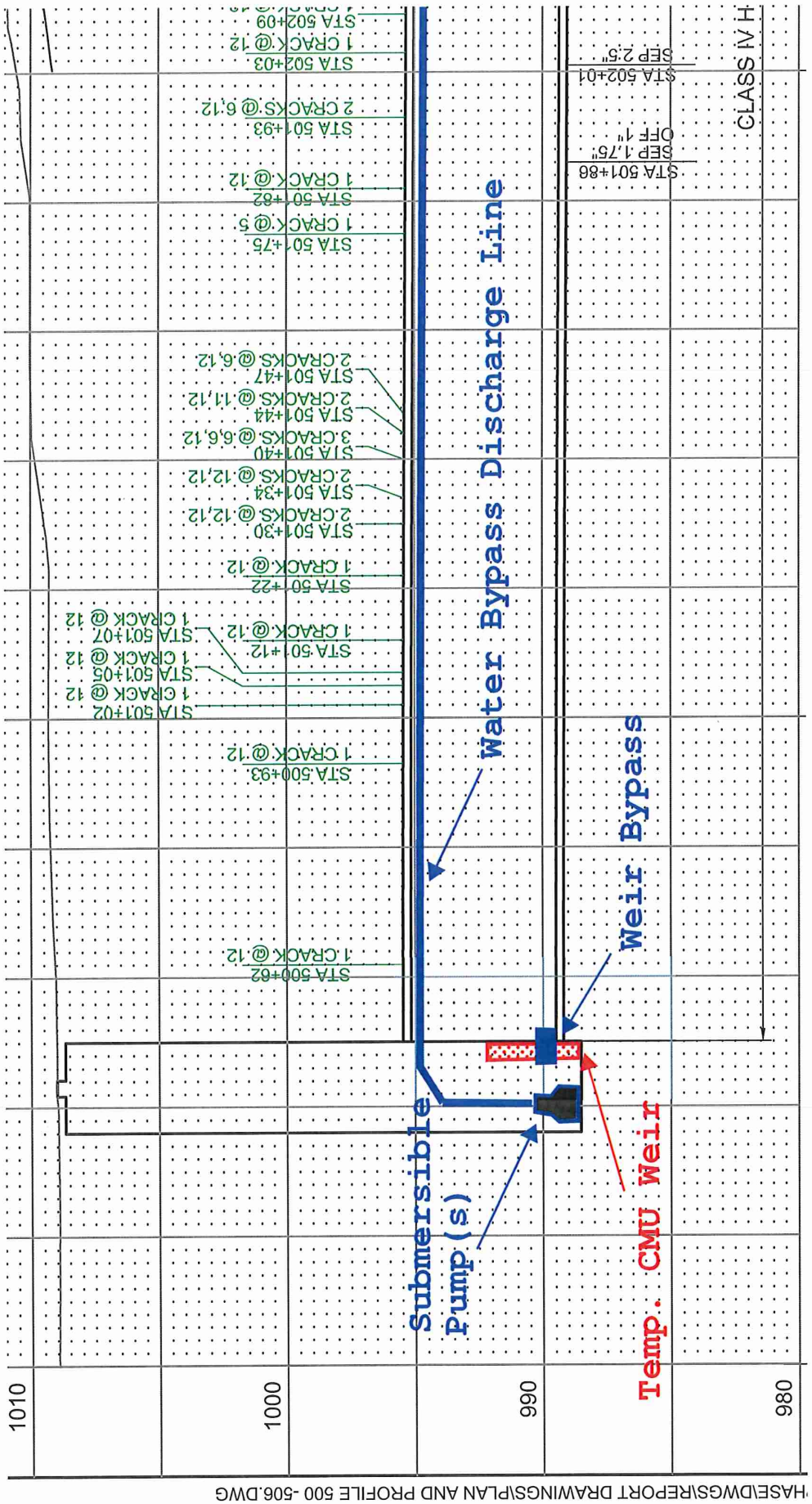
Shane McFadden, P.E.
President

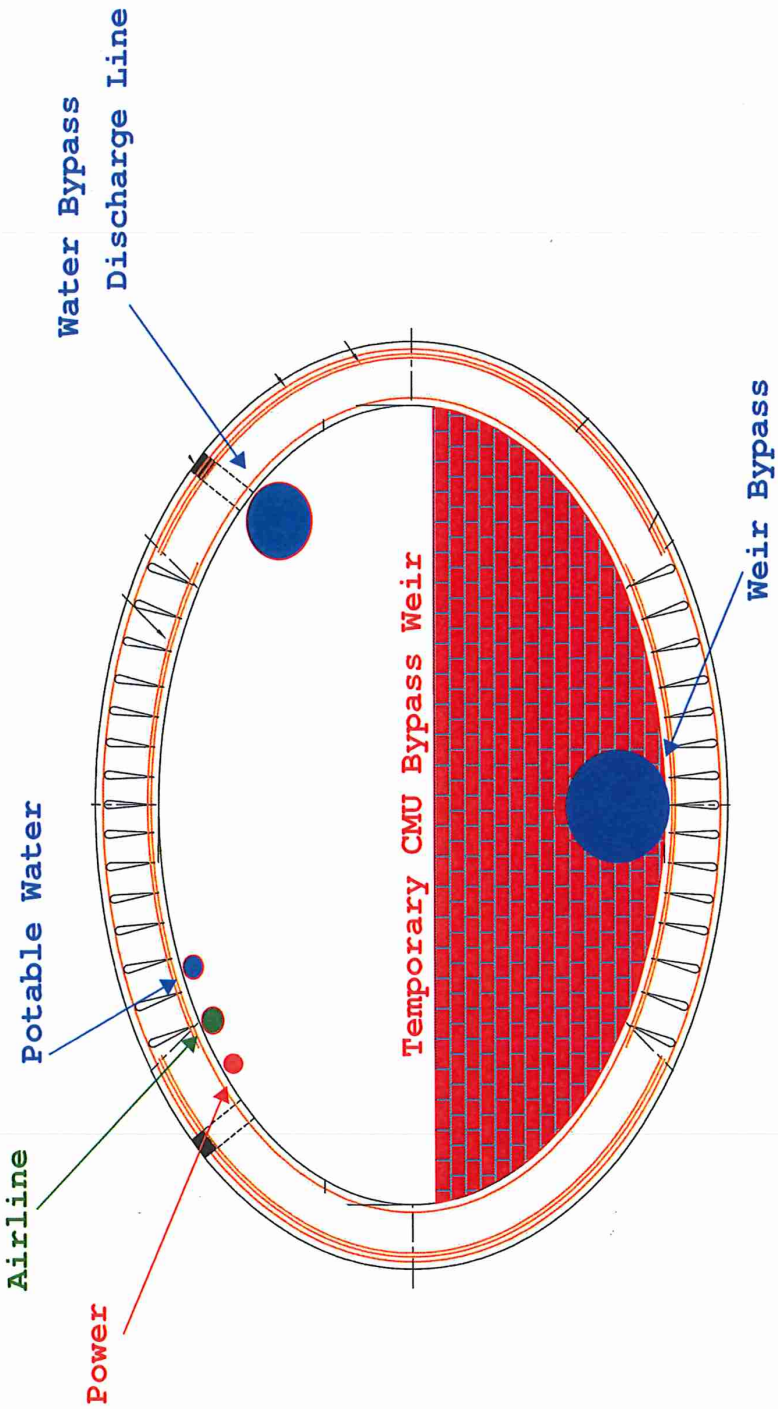
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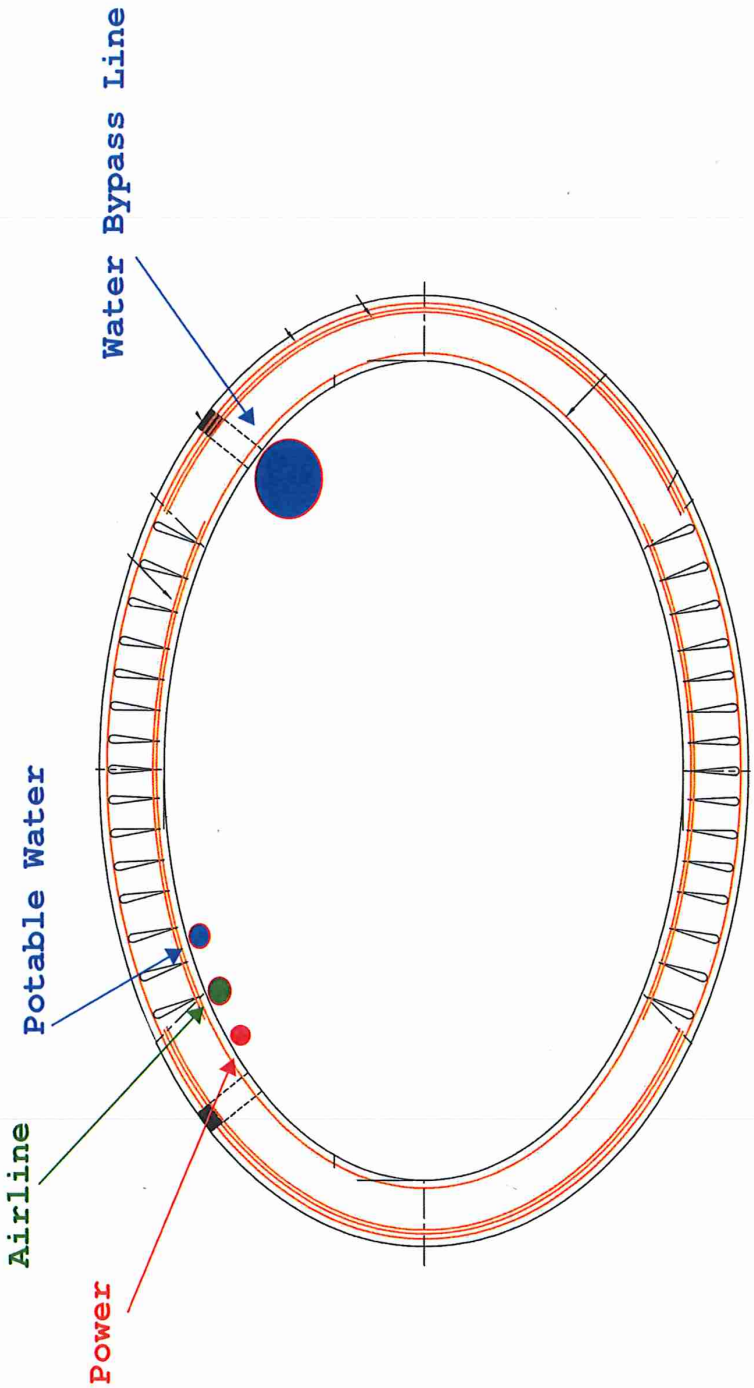
RAYMOND ROAD CULVERT PIPE RESORATION
VERONA, WISCONSIN

PROJECT BID SCHEDULE

Bid Item	Description	Units	Quantity	Unit Price	Total Price
01	Mobilization/Demobilization	LS	1.00	$ 250,000.00	$ 250,000.00
02	Site Setup	LS	1.00	$ 335,500.00	$ 335,500.00
03	Water Control	LS	1.00	$ 79,500.00	$ 79,500.00
04	Winter Protection	LS	1.00	$ 75,000.00	$ 75,000.00
05	Access to Work	LS	1.00	$ 135,000.00	$ 135,000.00
06	Clean Pipe	LS	1.00	$ 90,000.00	$ 90,000.00
07	Polyurethane Grout Joints	EA	469.00	$ 630.00	$ 295,470.00
08	Polyurethane Grout Material	GAL	3,300.00	$ 93.00	$ 306,900.00
09	Polyurethane Grout Material - Over 20% of Base Quantity	GAL	1.00	$ 65.00	$ 65.00
10	Acrylamide Grout Joints	EA	469.00	$ 515.00	$ 241,535.00
11	Acrylamide Grout Material	GAL	23,919.00	$ 23.00	$ 550,137.00
12	Acrylamide Grout Material - Over 20% of Base Quantity	GAL	1.00	$ 20.00	$ 20.00
13	Ultrafine Cement Soil Stab - 36" Penetration	EA	1,876.00	$ 165.00	$ 309,540.00
14	Ultrafine Cement Soil Stab - 24" Penetration	EA	1,876.00	$ 135.00	$ 253,260.00
15	Ultrafine Cement Grout Material	GAL	67,536.00	$ 15.00	$ 1,013,040.00
16	Ultrafine Cement Grout Material - Over 20% of Base Quantity	GAL	1.00	$ 13.00	$ 13.00
17	Crystalline Waterproofing: <= 0.02" Cracks	LF	1,714.00	$ 6.50	$ 11,141.00
18	Polyacrylate Grout Crack Injection: >0.02" Cracks	LF	275.00	$ 69.00	$ 18,975.00
19	Epoxy Resin Crack Injection	LF	54.00	$ 60.00	$ 3,240.00
20	Thermoplastic Sheet Strip Seals	EA	71.00	No Bid	$ -
21	HydraTite Internal Joint Seals - Alternate to Bid Item 20	EA	71.00	$ 3,395.00	$ 241,045.00
22	Cementitious Mortar Fill	EA	128.00	$ 60.00	$ 7,680.00
23	Invert Static Cone Penetrometer Test	EA	469.00	$ 17.00	$ 7,973.00
24	Pre-Ultra Fine Cement Grout Static Cone Penetrometer Test	EA	938.00	$ 17.00	$ 15,946.00
25	Post-Ultra Fine Cement Grout Static Cone Penetrometer Test	EA	938.00	$ 39.00	$ 36,582.00
	PROJECT TOTAL				**$ 4,277,562.00**

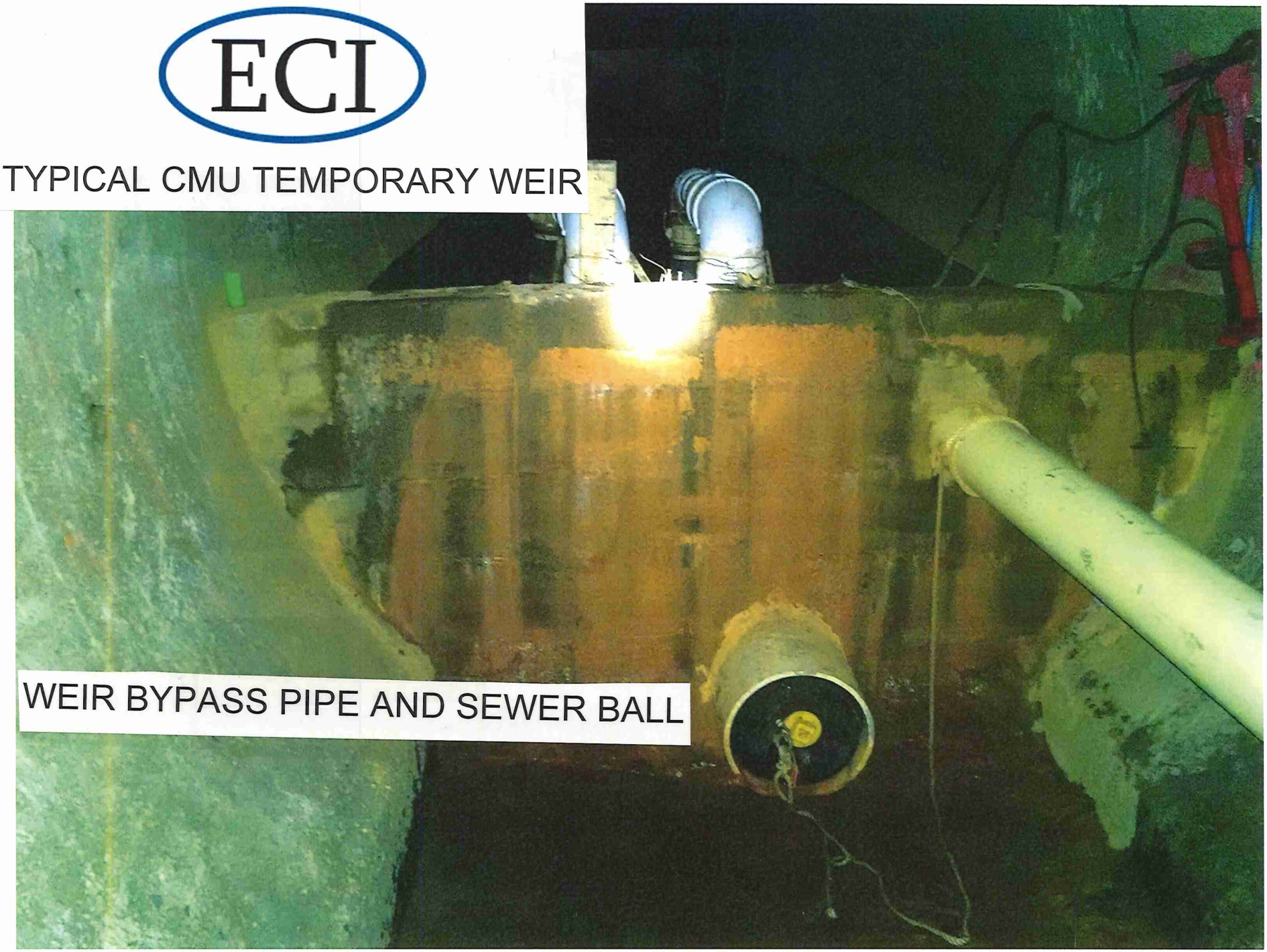

Water Bypass Discharge Line
Weir Bypass
Submersible Pump(s)
Temp. CMU Weir
1010
1000
990
980
CLASS IV H
STA 501+86
SEP 1.75"
OFF 1"
STA 502+01
SEP 2.5"
STA 502+09
1 CRACK @ 12
STA 502+03
2 CRACKS @ 6,12
STA 501+93
1 CRACK @ 12
STA 501+82
1 CRACK @ 5
STA 501+75
2 CRACKS @ 6,12
STA 501+47
2 CRACKS @ 11,12
STA 501+44
3 CRACKS @ 6,6,12
STA 501+40
2 CRACKS @ 12,12
STA 501+34
2 CRACKS @ 12,12
STA 501+30
1 CRACK @ 12
STA 501+22
1 CRACK @ 12
STA 501+12
1 CRACK @ 12
STA 501+07
1 CRACK @ 12
STA 501+05
1 CRACK @ 12
STA 501+02
1 CRACK @ 12
STA 500+93
1 CRACK @ 12
STA 500+62
HASE\DWGS\REPORT DRAWINGS\PLAN AND PROFILE 500 -506.DWG


Water Bypass
Discharge Line
Weir Bypass
Temporary CMU Bypass Weir
Potable Water
Airline
Power


Water Bypass Line
Potable Water
Airline
Power

ECI

TYPICAL CMU TEMPORARY WEIR



WEIR BYPASS PIPE AND SEWER BALL



ECI

TYPICAL TUNNEL UTILITY SET UP WITH
WATER BYPASS DISCHARGE PIPE

Engineering & Construction Innovations, Inc.

RAYMOND ROAD CULVERT PIPE RESTORATION

PRELIMINARY NIGHT SHIFT OPERATIONS PLAN

January 2020

7002 6th St. North ◆ Oakdale, Minnesota 55128
TEL: 651-298-9111 ◆ FAX: 651-298-9113 ◆ www.EandCI.co

Purpose:

To define the general operations and chain of command for night shift operations to accelerate the execution of the defined restoration program.

Summary:

ECI is prepared to execute the work associated with the defined restoration program utilizing a second/night shift if allowed by Integrity and the project Owner. The utilization of a second shift will substantially reduce the overall duration of the project and exposure to potential weather-related delays. The work hour and shift arrangement would be as follows:

- Day/First Shift: Monday through Friday 7:00am to 5:30pm
- Night/Second Shift: Monday through Friday 5:30pm to 4:00am

At this time, the second shift would only be implemented during the culvert grouting operations. A breakdown of the shift work application is as follows:

- ***Single Shift Operation:***
    - Mobilization
    - Site Setup
    - Access to Work
    - Setup Water Control
    - Setup Tunnel Utilities
    - Culvert Cleaning
    - HydraTite Internal Joint Seals
    - Crack-sealing
    - Cleanup/Reclamation
    - Other Work
    - Demobilization

Double Shift Operation:

- Polyurethane Grout Joints
- Acrylamide Grout Joints
- Ultrafine Cement Soil Stabilization

It is anticipated that the project will be staffed with a full time Project Engineer and a full time Project Superintendent on day shift and a full time Shift Superintendent for the night shift. Working under the Superintendents will be Crew Forepersons that will manage each individual crew. During the height of the operations, ECI anticipates that there will

be up to 21 workers on day shift and 20 workers on night shift. It is anticipated that the night shift will be in operation for a duration of approximately 50 continuous working days based on currently anticipated grout volumes. This does not include any weather-related impact delays. Please note that the manpower loading and schedule are subject to change based on the final defined restoration program and site specific requirements and constraints.

ECI will provide adequate lighting for safe site surface operations (e.g. grout batching and pumping) during nighttime hours. The culvert will be equipped with tunnel lighting and/or personnel lights (cap lamps) for both day and night shift operations. No specific consideration has been made for shielding or deflecting light from the Public.

ECI anticipated that the following equipment will be employed on the surface during night shift operations:

- Pickup Trucks
- Skid Steer Loader
- Small Telescopic Boom Hydraulic Crane (50 ton class or less)
- Telescopic Boom Forklift
- 75kW Generator, up to two
- 375 CFM Air Compressor, up to two
- Colloidal Mixing Grout Pump, up to two
- Polyurethane Grout Mixing and Pump System
- Acrylamide Grout Mixing and Pumping System

Enclosures will be constructed for the grout mixing operations to provide heat control and weather protection. No specific consideration has been made to address specific local noise ordinances or to provide additional noise muffling of equipment.

This preliminary plan will be modified as necessary based on the final defined restoration program and site-specific requirements and constraints.

Engineering & Construction Innovations, Inc.

RAYMOND ROAD CULVERT PIPE RESTORATION

AFTER HOURS NOISE ABAITMENT PLAN

March 11, 2020

Engineering & Construction Innovations, Inc. (ECI) anticipates conducting night shift operations during the work week (Monday through Friday) on this project. In order to mitigate noise, all stationary surface equipment noise output will be kept below 100 dB at a distance of 20 feet from the equipment. The surface equipment will be staged away from residences in wooded areas wherever possible. Supplemental noise abatement measures (i.e. sound walls, enclosures, etc.) will be taken to keep the noise output levels below 100 dB at 20'.

The following is a list of stationary and mobile equipment anticipated to be on the project:

Stationary Equipment:	Mobile Equipment:
- 375 CFM Air Compressor - 45kW Generator - Mobile Light Plant - Chemgrout CG-600 Grout Plant - Graco 1:1 chemical grout pump - PowerCreter PC20 Concrete Pump	- Pickup Truck - Skid Steer - Telehandler - Carry Deck Crane

7002 6th St. North ◆ Oakdale, Minnesota 55128
TEL: 651-298-9111 ◆ FAX: 651-298-9113 ◆ www.ECIconstructors.com

resourceful. naturally.
engineering and environmental consultants

BARR

February 28, 2020

Mr. Dan Weinkauf
Integrated Grading & Excavating (IGE), Inc.
605 Grossman Drive
Schofield, WI 54476

Re: WisDOT Review Comments on the Work Plan for Investigation of the Backfill for the Raymond Road Project, Verona, WI

Dear Mr. Weinkauf:

Barr Engineering has reviewed the comments submitted by the Wisconsin Department of Transportation (WisDOT) in February 2020 regarding the Barr Engineering Updated Work Plan for Geophysical Investigation Oversight, and Evaluation of Mitigation Alternatives for Backfill, Raymond Road, Verona, WI dated January 22, 2020.

The Barr work plan specifies necessary initial investigation details required to collect the data necessary to establish thresholds for mitigation that has been requested by WisDOT. We believe that we have an obligation to first evaluate the in-situ soil conditions prior to proposing mitigation details including determinative thresholds.

The investigation will identify the specific intervals and locations that require mitigation. Therefore, moving forward with the MASW investigation and the ground truth appears to be the most reasonable path forward. We agree with WisDOT that an interim report summarizing the data and our recommended actions for mitigation of the backfill prior to mitigation are a reasonable path forward. We believe that an interim report summarizing the data and our specific recommendations on the backfill remediation targets can be submitted to IGE within 30 days of completion of the field work.

If you have additional questions please contact Jim Aiken at jaiken@barr.com or (952) 832-2740

Sincerely,

James S. Aiken, PG
Wisconsin Professional Geologist #00317
Vice President

Work Plan

Geophysical Investigation and Mitigation of Backfill

Raymond Road, Verona, WI

Prepared for
Integrity Grading & Excavating, Inc.

January 22, 2020

Work Plan

Geophysical Investigation and Mitigation of Backfill

Raymond Road, Verona, WI

Prepared for
Integrity Grading & Excavating, Inc.

January 22, 2020

Work Plan

Geophysical Investigation for Mitigation of Backfill

January 22, 2020

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Appendix A Response to WisDOT Comments
Appendix B Description of MASW

Certifications

I certify that this subsurface investigation work plan was prepared by me or under my direct supervision and I am a duly licensed professional geologist in the State of Wisconsin.

Jame S. Aiken, P.G.
PG #: 00317

WISCONSIN JAMES S. AIKEN 00317 Bloomington MN PROFESSIONAL GEOLOGIST

January 22, 2020
Date

I certify that the the engineering elements of mitigation alternatives within this work plan were prepared by me or under my direct supervision and I am a duly licensed professional engineer in the State of Wisconsin.

Travis A. Davidsavor, PE
WI Professional Engineer E-39112-6

WISCONSIN TRAVIS A DAVIDSAVOR E-39112-6 DULUTH, MN PROFESSIONAL ENGINEER

January 22, 2020
Date

1 Introduction

This work plan has been developed for the Raymond Road roadway project (Site; Figure 1) and has been prepared based on our understanding of the project requirements and conversations with the Wisconsin Department of Transportation (WisDOT). The problem addressed by this investigation is specifically related to subsidence features that appeared in the roadway surface along a newly constructed storm sewer pipe alignment under Raymond Road near Verona, Wisconsin. Previous investigations have indicated that the cause of previous subsidence features along the sewer pipe alignment were due to inadequate seals in the sewer pipe that allowed mobilization of backfill soil into the pipe and subsequent loss of soil density due to fines migration out of the backfill and into the sewer pipe. WisDOT has required that Integrity Grading & Excavating (IGE) provide plans to mitigate the issues with the storm sewer to prevent future subsidence and/or other problems with the sewer pipe.

This work plan has been updated and revised based on comments from the WisDOT in response to a letter work plan prepared by Barr and submitted on November 4, 2019 by IGE, who is Barr's client for this work.

In a meeting on January 9, 2020, WisDOT requested the responses to their questions and concerns be included into a work plan format. Appendix A includes our specific response to those comments and reference to where they have been incorporated into this work plan.

1.1 Purpose

The purpose of this project is to identify potential low density soil areas within the soil backfill above the storm sewer pipe alignment under Raymond Road. The goal of the investigation is to provide data necessary to make engineering decisions to recommend and implement corrective actions to mitigate areas of the subsurface with low density soil. This mitigation may include reducing voids and/or densifying soft soils so that they do not contribute to future subsidence features in the backfill above the sewer pipe.

The backfill areas addressed in this work plan are specific to areas above the elevation of horizontal midpoint of the pipe section referred to herein as the spring line. This plan is one part of IGE's overall plan to address the subsidence features and pipe joint condition. The other plan (Pipe Mitigation Plan; prepared by others under separate cover) addresses sealing of the pipe joints and correction of backfill under the pipe spring line. That scope of work is not included in the work to be performed by Barr and its subcontractors. Both mitigation teams will share information so that the overall mitigation may be satisfactory to IGE and WisDOT.

1.2 Scope of Work

The following tasks are proposed and have been developed based on the previous work completed by Barr and others at the Site and include and are described as:

- **Project Management** – This task will include coordination with subcontractors, meeting with clients and WisDOT, and project administration including preparation of this work plan.
- **Subcontract qualified contractors –** This task includes obtaining proposals and contracting experienced providers to conduct the geophysical and geotechnical investigation, perform ground truth activities, and identification of appropriate mitigation contractors.
- **Mobilization** – Preparation and mobilization of staff, equipment, and subcontractors to the site, conduct required safety and utility meetings.
- **Conduct Initial Geophysical Survey** – A geophysical survey using Multichannel Analysis of Surface Wave (MASW) method will be subcontracted to 3DGeophysics to identify areas with relatively low density backfill that might be associated with future subsidence
- **Conduct Ground Truth Correlation** – This task includes physical testing of areas in the backfill indicated by the geophysical data to consist of relatively low, medium, and high velocity soils which are expected to correlate to respective low, medium and higher density soil. The ground truth will allow the geophysical data to be used to prioritize and focus those areas that are at relatively higher risk of future subsidence potential. This activity will be conducted using a subcontractor to perform cone penetration testing (CPT), and or standard penetration testing (SPT), or basic excavation and direct observation and soil density testing using standard excavating equipment.
- **Data Assessment** – After the investigation is complete, the data collected during the previous tasks will be evaluated to identify the depth and extent of areas that demonstrate potentially soft or loose soils that may indicate higher risk for future subsidence. This information will then be reviewed by Barr's geotechnical engineers to identify specific actions and mitigation measures proposed for each area. The mitigation actions will be specifically recommended based on the area, depth, and degree of anticipated mitigation effort.
- **Conduct Mitigation of the Backfill** – At this time, low-mobility compaction grouting and/or excavation and backfill of soils are anticipated. These methods may not be suitable for specific conditions, but at this time, with the information available, are considered to be appropriate and effective technologies. Based on the data assessment, Barr will provide recommendations for IGE to contract with a qualified grouting contractor to complete the mitigation tasks. Barr will provide construction observation services during the mitigation process. Although this work plan provides conceptual alternatives for mitigation, it is not possible at this time to predict specific thresholds for the types of mitigation used in specific locations without first collecting the investigation data needed to assess which areas require mitigation.
- **Confirmation Survey** – This task will include a follow up MASW survey combined with limited ground truth using CPT and/or SPT methods that will be conducted after the mitigation of the backfill is complete. This information will be used to assess whether the mitigation has been effective and that no evidence of new areas of subsidence, low density soils, or other voids has developed. If there is evidence that soft or loose soils persist in areas previously documented and mitigated, or new areas are identified, additional mitigation efforts may be required.
- **Investigation & Mitigation Report** – This task will include a summary of the mitigation and confirmation tasks along with recommendations for future work and/or monitoring, if needed.

2 Background Information and Rationale for Proposed Work

This section provides a summary of existing information and findings of previous work that support the basis for the work proposed in this plan.

2.1 Area of Investigation

The project area is located along an approximately 3,300 foot section of Raymond Road located northeast of Verona, Wisconsin and consists of the area under Raymond Road that is above the alignment of pipe located between approximate station locations 500+50 at the western extent of the pipeline and 532+79 at the eastern storm sewer pipe outlet.

The recently constructed 68"x106" elliptical concrete pipe run coincides with reported subsidence features documented along the sewer pipe alignment. These features were reported to have been discovered in fall 2018 and spring 2019 and occurred along the approximately 1,000-foot long lower reach of the pipe run from approximately stations 522+00 to 532+00.

Figure 2 provides the location of the entire project area. Figures 3 through 5 show investigation details of the eastern, central and western portions of the pipe including previous borings and test trenches. The approximate location of the six reported subsidence features, noted as red and yellow circles and labeled SF, are also shown in Figure 3. Figures 4 and 5 show the central and western extent of the piping run where subsidence features have not been observed to date, but that were previously investigated with soil borings and that will be part of the area of geophysical investigation.

2.2 Previous Investigations

Six previous subsidence features were observed and locations documented as shown on Figure 3. All of the subsidence features under the roadway were excavated to several feet below the road surface and re-compacted shortly after their discovery in June 2019.

Barr Engineering was hired to conduct a subsurface investigation of the backfill above the sewer pipe in July 2019 which included soil auger borings with Standard Penetration Testing (SPT) at or near each subsidence feature, and installation of nested piezometers to document soil saturation in the backfill adjacent to the sewer pipe and test trenching. The subsidence features documented by IGE were on the order of several feet wide and up to several feet deep. All of the features appeared to coincide with the alignment of the sewer pipe, indicating that pipe itself and the backfill are involved as potential causes for the subsidence features.

Although soft and loose soils in the backfill were noted at several locations during the investigation, these loose soil conditions were also were present in the backfill along the pipe at locations that were not

associated with subsidence features. These locations at which subsidence was not observed, but investigation occurred, were considered control locations. Conversely, relatively dense soils were observed at both the control borings and under the subsidence features (below the level previously backfilled and compacted). Based on these observations, loose backfill or soft soils alone could not solely be considered to explain the presence or cause of the subsidence features.

In addition, three of the previous subsidence locations (SF2, SF4, and SF6) were excavated down to the top of pipe for visual observation of the backfill and pipe joints. Soil density testing was performed in the excavations using nuclear density gage (ASTM, 2010) and sand cone density (ASTM, 2015) tests. After data collection activities, all three of the test trenches were backfilled with compacted silty sand material excavated from above the pipe. Soil compaction in the test trenches was documented by field density testing to be equal to or greater than 90% standard proctor density (ASTM, 2012, a) in most cases. Clay and clayey-silt soils discovered in test trench 3 revealed compaction range from approximately 83% to 89% standard proctor density. No test trenching was conducted at locations SF1, SF3, and SF5 due to proximity to utilities and time constraints.

A second subsurface investigation was conducted by Soil Engineering Services for information needed in preparation of the Pipe Mitigation Plan submitted by IGE. That investigation indicated similar variation of soil density between soil types and depths. A total of 19 soil borings were completed between October 1 and 4, 2019, along the extent of the sewer pipe alignment from approximate station locations 502+00 to 531+76. Clay, clayey sand, and silt exhibiting relatively low soil density, was observed adjacent to the pipe in isolated areas along the extent of the sewer pipe alignment.

Several lines of evidence indicated that the pipe joints were a likely cause of the subsidence features. This conclusion was based on the presence of fine sediments in the pipe joint, evidence of elevated water levels around the pipe observed in the piezometers during rainfall events that filled the pipe, significant sediment being discharged by the outlet of the pipe, and the lack of soil and water-tight seals in the joints between the pipes. Indirect lines of evidence indicated that high water table conditions are also related to the subsidence features. This evidence included the presence of large quantities of silt at the pipe outfall, the occurrence of the features in areas where the pipe is within or close to the water table, and documents that indicated wet conditions were present during installation of the pipe.

2.3 Conceptual Site Model for Backfill

A Conceptual Site Model is a simplified representation of the conditions anticipated based on previous information that forms a basis for how the investigation goes forward and what types of outcomes may be expected. This information was added to the work plan to address WisDOT request to better define the supporting rationale for the investigative methods selected and the potential outcomes that will drive the selection of mitigation alternatives. Information on mitigation alternatives are described in Section 3.7.

The proximal cause of the subsidence features is believed to be the mobilization of fine sand, silt and clay particles into the pipe joints of the sewer pipe during and after fluctuations in water table conditions

within the pipe and the backfill. Although the joints were sealed with mastic, this material was apparently ineffective in preventing soil migration into the pipe joints. Based on the information described in previous investigations, multiple lines of evidence indicate that the subsidence was largely due to the loss of soil mass that started near the pipe.

The presumed mechanism for subsidence features is that the volume lost from fines migration through the pipe joints into the pipe resulted in a loss of soil density near the pipe joints. This may have resulted in lowered soil density near the pipe. The weight of the overlying soil under this scenario would have caused deformation of the low density soils as the overlying soils moved downward to fill in the loose or eroded area. The settlement of the overlying soils into lower layers would then have translated a similar deformation pattern incrementally upward to the surface, finally resulting in a depression at the ground surface. For layered backfill, this would appear as successive layers showing a series of bowed and offset layers that start in lower soils and appear to migrate vertically to the surface.

The problem also may have been exacerbated by infiltration and saturation of overlying soils during rainfall events. Rainfall for Madison, WI in 2018 was 16.5 inches above the annual average, which was the 2nd wettest annual precipitation in 150 years of historical data. This record year was followed by another wet year in 2019 which was 12 inches above average (US NWS, 2018, 2019). The wet conditions likely resulted in high water table conditions and elevated antecedent moisture conditions within the backfill that may have been a factor in the formation of the subsidence features.

Infiltration from above could have collected into surface depressions saturating soils below the roadway surface making them weaker and more subject to deformation and subsidence. Another condition might involve the combination of scenarios above where a subsidence feature originating deeper in the fill causes a depression in the ground surface which is then filled with runoff creating saturated conditions in the soil above the location of the subsidence feature.

To our knowledge, no subsidence features have been reported along the approximately 2,300 foot southwest portion of the Raymond Road storm sewer alignment between approximate station locations 502+00 and 521+00. The lack of observable subsidence features within this interval may be due to the elevation of the water table decreasing relative to the pipe in this area, or the increased depth of the sewer below the ground surface. It is also possible that the greater thickness of fill in some areas allowed for accommodation of the lost soil mass by overlying soils or soil bridging.

Based on this conceptual model, sealing of the joints to prevent future loss of soil volume should reduce the potential for future subsidence features. However, the investigation is also intended to identify the location and the condition of the soils that may have previously lost some soil mass through the unsealed pipe joints. These hypothetical conditions may not have resulted in subsidence features because the overlying soils may not yet have settled into the lower density soils. The purpose of the investigation is to identify low density soil areas and direct mitigative actions so that that future subsidence can be avoided. The investigation methods described below are intended to detect these lower density soils so that appropriate mitigative efforts can be implemented.

2.4 Investigative Methods

Based on the nature of the backfill and the variability of the backfill soils, several investigative methods may be employed to evaluate the subsurface. The first method that will be used, MASW, is a surficial geophysical method that is not invasive and is used to target or prioritize subsequent physical investigation. The CPT, SPT, and excavation aspects of the investigation allow for observation with direct quantitative measures, correlations, and can be used in defining mitigation areas.

2.4.1 MASW

Geophysical investigation methods include applying an energy source to the subsurface and recording the response returning to sensors or monitors to interpret the properties of the soil material. After a discussion of site conditions and a review of available and suitable geophysical technologies with 3DGeophysics, we proposed the MASW geophysical method. This method is a type of seismic exploration technique that evaluates ground stiffness of soils by measuring dispersion of seismic waves at a variety of frequencies. The seismic source is a hammer and the ground response is measured with an array of geophones laying on the ground surface. An explanation of MASW is included in Appendix B.

The MASW survey is capable of identifying soils with low shear wave velocity that correlate to soils with low density above and adjacent to the sides of the storm sewer within the storm sewer trench excavation. Because the rate at which sound waves travel through these materials is a function of the shear strength of those soils, high shear strength is correlated to higher velocity and lower soil shear strength indicates lower velocities. Soils with a higher shear wave velocity typically have higher soil density, and conversely, lower shear wave velocities correlate to lower density soils.

Investigation data is expected to show a profile of the backfill similar to the profile in Appendix B that will show depth intervals of higher or lower shear wave velocity. Low density areas or areas of higher void space (filled with either air or water) appear as anomalies of lower wave velocity in a matrix of higher shear wave velocities. The resolution of the investigation is on the order of 1 meter which is consistent with the scale of the subsidence features previously observed along the pipe alignment. As with any geophysical method, application of the data requires "ground truth" which means the use of a direct physical measurement. Ground truth will be performed to confirm and correlate the soil properties indicated by the MASW survey.

2.4.2 Cone Penetration Testing (CPT)

Cone Penetrometer Testing (CPT), generally performed in accordance with ASTM D5778-12, will be the primary tool used in ground truth because it is a well-established technology for measuring soil properties in a continuous profile with higher accuracy. Barr has worked with several CPT contractors across the US and Canada on hundreds of projects. For this project, Barr will ensure that the ground truthing CPT contractor is qualified and experienced. CPT will be used on this project to provide a continuous profile of tip resistance along with side friction of the cone that can be correlated to soil stiffness and the density profile of the soils imaged with MASW. Obstructions such as frozen ground,

dense gravels, cobbles, boulders, and bedrock may result in refusal for the CPT probe; therefore the CPT method is often combined with a standard auger boring rig to allow for drilling through obstructions and then resuming the CPT profile below the obstruction. If this process becomes too slow due to gravel in the backfill, it is typically more cost effective to switch to SPT methods described below.

2.4.3 Standard Penetration Testing (SPT)

At several locations SPT sampling will be performed to recover soil samples to measure soil density in the laboratory. In the event that we are not able to use CPT for ground truth, for example where soils are hard to very dense, we will also use hollow stem auger drilling with SPT sampling methods (ASTM, 2018). Although less precise than CPT, the SPT method will provide a method of collecting ground truth data on soil density for correlation to the MASW. This method will also be used to collect soil samples at several locations where CPT and MASW indicate that there are soft cohesive soils. Although these two types of materials may exhibit a similar MASW profile indicative of low density soils, the differences observed in the MASW data will likely allow a means to identify subtle differences in soil materials. These differences could influence the selection of mitigative actions at locations that appear to be related to specific soil types and mitigation strategies. For example, a significant thickness of soft clay may justify excavation and re-compaction as opposed to compaction grouting by injection.

2.4.4 Excavation Trenches

The excavations are useful where direct observation of soil characteristics are needed. For shallow soils where low density soils are suspected, a small number of test trenches may be performed to explore the near surface areas to identify the cause of velocity contrasts on the MASW output that cannot be resolved using CPT or SPT methods. Soil density testing can also be measured directly in the test trench using nuclear density testing or sand cone methods. This option may also be used where frozen soils (if present) are suspected to directly observe the conditions where the apparent stiffness of shallow soils that cannot be assessed accurately with MASW, CPT, or SPT.

3 Task Descriptions

3.1 Project Management

This task includes subcontracting, preparation, and project administration tasks such as budgeting and file management. If required, this task includes time and materials estimates for additional meetings with WisDOT and progress updates.

3.2 Subcontract Qualified Contractors

This task includes obtaining proposals and contracting experienced providers to conduct the geophysical and ground truth activities, and identification of mitigation contractors. Once the work plan is approved, we will engage qualified and experienced contractors like 3DGeophysics for the MASW, and additional qualified and experienced contractors for CPT and drilling. It is likely that we will also contract with one or more of the vendors that were utilized during the previous subsurface investigation to provide additional drilling services, laboratory, and surveying. The mitigation and excavation and re-compaction contractors will be qualified and experienced.

3.3 Field Coordination and Mobilization

This task consists of preparation and coordination of subcontractors and mobilization to the field. This task will also include working with other entities on the team to ensure that permits, work hours, and safety concerns are communicated amongst the project team. Utility locates for the subsurface investigation will be handled by each respective subcontractor.

3.4 Conduct Oversight of Initial Geophysical Investigation

This task will include field oversight and documentation of the geophysical investigation and working with 3Dgeo to evaluate the data and identify the locations and depths of apparent velocity anomalies that may be associated with low density areas at existing or potential future subsidence locations.

Three transects will be conducted along the entire approximately 3,300 feet of the pipe at the site. One transect will run along the roadbed surface along the centerline of the pipe alignment with two additional transects conducted along each of the outer edges of the pipe alignment.

Because the degree of soil saturation may influence the shear strength of soils and hence the MASW profile, it will be useful to identify the water table during the investigation. The water table will be defined at the time of the MASW investigation by recording water levels at piezometer nests that were installed during prior investigations. Up to three additional piezometer nest locations will be evenly spaced over the southwestern two-thirds of the pipe alignment. The piezometers (ASTM, 2012, b) will be positioned at a depth just below the pipe invert elevation. The nests will consist of a transducer attached to a rigid pipe section and will be secured in the borehole using by tremie grouting through the hollow stem auger.

3.5 Targeted Ground Truth

Targeted "ground truth" is an important step in evaluating geophysical data as it will allow correlation of the MASW investigation results by testing for physical parameters and measuring apparent soil density. Areas of high, medium, and low shear wave velocities will be included in the ground truth step to provide a correlation between wave velocity and soil stiffness.

The tools for ground truth may include a cone penetration test CPT rig, SPT testing with a hollow stem auger drill rig, or traditional excavation equipment. The CPT rig will be used to continuously observe the tip resistance of the soil at depth at 1-centimeter intervals at select locations. The tip resistance, in conjunction with the soil friction, can be used to correlate apparent density. The apparent density will then be correlated to standard proctor soil density tests (ASTM, 2012, c) obtained during the previous investigation. Additional in-situ tests will be conducted during the ground truth portion of the investigation. This will include about 5-10 thin wall samples that will be advanced with the hollow stem auger rig to evaluate soil sample density using direct observation of fine grained and cohesive soils. A small number of trench excavations may be completed to evaluate density of soil in shallow areas. The soil in the exposed excavation area will be tested with a nuclear density gage to document soil density.

Ground truth investigation measures will be undertaken at sufficient representative locations to refine the interpretation of the MASW results. For control, at least 10 areas of low velocity features, at least 5 locations with apparent medium density and at least 10 locations with high density features will be evaluated. It is assumed that a large portion of the low, medium, and high density features may be correlated at the same location by vertical profiling.

The data from previous borings will be used for ground truth along with new investigation locations. Although soil conditions assessed during the MASW investigation may require more sampling at certain locations, we anticipate a minimum of approximately 30 to 40 CPT locations, about 10 to 15 continuously-sampled SPT auger borings, and 5 to 10 shallow trench excavations in the pipe backfill. On average, this will result in a minimum of one ground truth location per every 100 feet of the pipe alignment.

3.6 Data Assessment

Once the data is collected, a registered professional engineer will evaluate and analyze the information to provide appropriate mitigation recommendations. The mitigation recommendations will depend on several factors including the depth, degree of density, soil type, and overall area and type of apparent low density soil or soil anomaly. The mitigation is intended to increase soil density in the low density backfill regardless of whether a distinct void is observed for the purpose of reducing or eliminating the development of subsidence that reaches the surface.

The decision process will identify zones for mitigation by first identifying priority areas. In general, the priorities for evaluating the backfill will be ranked according to the presence or absence of the following conditions:

1. Priority 1 Locations – The presence of low density soil located at shallow depth below ground surface and is estimated to occur over a wide area
2. Priority 2 Locations – Low density soil that is located at greater depth over wide area
3. Priority 3 Locations – Low density soil that is shallow but small in scale
4. Priority 4 Locations – Low density soil that is deeper and small in scale

Each of the priorities will be addressed by mitigation. In regards to the definition of the priority areas, shallow means that the anomaly is observed within about 3 to 7 feet of the surface and deep means greater than 3 to 7 feet below the surface. However, the degree to which soil density will be improved by mitigation in these areas may vary. This is because higher density soils are required immediately under the road way to accommodate anticipated traffic loads. Lower density soils may be acceptable in deeper sections of the backfill because the stress imparted by the surface loads are dispersed with depth.

Based on the conceptual model described in Section 2.3, the deeper backfill material must be sufficiently dense to resist deformation and settlement of overlying soils assuming that the Pipe Mitigation Plan is successful in preventing future fines migration. The practical threshold in these deeper areas will be the degree to which these soils will accept grout injected into or adjacent to the loose soils. It is assumed that grout will greatly increase the density of the soil which will be reflected in the confirmatory MASW survey described in Section 3.5. The confirmatory survey will also be verified by ground truth intended to demonstrate that the density of the grout injected into the targeted zone has increased. If the mitigated area is still showing low apparent density, additional grouting will occur so that the potential for settlement of the overlying soil column is further reduced.

3.7 Mitigation and Subsequent Work

The following sections provide information on mitigation, which will be completed after the proposed geophysical subsurface investigation, based on current knowledge of the site conditions and previous investigations discussed in Section 2.

3.7.1 Conceptual Mitigation Alternatives

The selection of a mitigation strategy and the relevant details needed to target each type of low density feature require knowledge of the subsurface provided by the proposed investigation. Without this information, it is not possible to accurately describe the type of mitigation that will be performed at each location to achieve an acceptable outcome, or the threshold values that will determine the mitigation activity. The standard of care for this effort requires that a professional engineer weigh these factors prior to recommending a solution. Regardless of the findings, the following discussion provides information on how the decision process will work given what is known about the backfill properties.

The anticipated primary tools for mitigation may include compaction grouting using low mobility grout, as well as excavation and re-compaction. If other methods appear suitable based on the review of the investigation by the professional engineer, they will be considered and discussed with WisDOT prior to recommendation. Based on the data collected via the ground truth process described in Section 3.5, each

low density anomaly will be mitigated as recommended by a registered professional engineer by one or more of the following techniques:

- **Low Mobility Compaction Grouting** – It may be appropriate to utilize a compaction grouting method that incorporates low mobility grout injected under pressure to densify soils. The grout would essentially take up the equivalent volume that was lost due to fines migration and at the same time increase the resistance to future accommodation and hence, settlement potential. This method is most suitable where sufficient overburden stress is developed to provide resistance to the introduced grout bulb. Typically, if the anomalies appear to be low density soils at depths greater than about 7 feet from the surface (depending on overlying soil density), sufficient confining stress can be provided to cause soil densification with limited surface heave. These methods utilize a drill rig that employs direct-drive or rotary drilling methods to insert a casing in which low-mobility grout is pumped. The grout is pumped under pressure from the bottom of the casing in stages to densify the surrounding soils. The process of installing the casing can be observed to qualitatively aid in evaluating the site specific in-situ soil density.

- **Excavation and Re-compaction** - If the ground truth suggests a shallow larger zone of loose soil, excavation, backfill, and re-compaction may be a more appropriate method. This method is preferred where the low density soils are generally less than 3 to 7 feet bgs and/or form diffuse zones of low velocity (loose) backfill that cover a larger area than a definable zone. Soil would be excavated to the target depth, the surface soils re-compacted and subsequent lifts placed and compacted in accordance with the roadway project specifications. Soils would be replaced and compacted as required in the original project construction documents and specifications.

3.7.2 Confirmatory Geophysical Survey and Geotechnical Investigation

After the low density anomalies are identified and mitigated, a follow up MASW survey transect will be conducted along the full 3,300 feet length of the pipe to evaluate the improvement of the low density areas observed during the preliminary investigation. Although new anomalies are not anticipated, the confirmation survey will also verify that no new anomalies have been formed since the preliminary survey. If such features are discovered during the confirmatory survey, those features will be addressed in a manner consistent with the methods described in Task 3.5 above. In addition, this confirmatory task will include approximately 10 to 12 CPT locations to verify the apparent density of soils and grout shown on the confirmatory MASW profile.

3.7.3 Summary Report

The results of the MASW geophysical investigation and ground truth efforts will be described in a summary report. The report will provide the output from the MASW survey in the form of cross sections with stationing, visual cross sections of soil types observed during drilling and tabulated data showing samples of 1-D MASW readings correlated to SPT and CPT data, as well as piezometer and boring logs, density tests, and other data relevant to the scope of work. The report will contain a summary of the

mitigation activities, as well as figures, tables, and appendices that show the referenced data locations and describe the applied mitigation methods.

The report will be prepared by a Wisconsin-registered professional engineer and professional geologist. The report will also include mitigation recommendations made by the professional engineer for locations along the storm sewer right of way that may require additional mitigation or monitoring. Once the report is accepted by WisDOT, the piezometer nest riser posts will be cut off at the ground surface and above-ground data loggers will be removed from the roadway area.

3.7.4 Monitoring

One of the recommendations in the summary report may include the need for future monitoring. After the investigation and mitigation provides an understanding of subsurface conditions above and adjacent to the pipe, informed decisions can be made when determining if a monitoring program is necessary. If required, a follow up MASW survey may be conducted approximately 4 months after the mitigation has been completed to evaluate relative density of the backfill and identify potential new low velocity anomalies.

4 Schedule

The project is estimated to require approximately 16 to 18 weeks to complete from the start date with accommodation for contractor availability and weather related delays. Delays at each stage of the project may result in delays in subsequent stages of the work and the final report. Components of the approximate schedule are provided below:

Weeks 1-3	Notice to proceed; contracting; utility locates arranged and documented. Project management, subcontracting, and preparation tasks initiated.
Weeks 3-4	3Dgeophyiscs mobilizes to Site and survey conducted. Supporting field equipment (drill rig, CPT rig, and excavator) are mobilized to the Site within a few days after MASW investigation starts.
Weeks 5-6	Data reduction and assessment. Mitigation method recommendations are finalized and provided based on target depths and area.
Weeks 6-12	Mitigation actions deployed (depends on number and location of anomalies, weather, and mitigation methods used); confirmatory geophysical survey begins in mitigation areas.
Week 13	Mitigation continues (if needed); confirmatory geophysical survey and investigation completed; data reduction and evaluation begin.
Weeks 13-17	Data reduction, summation, and draft report preparation; draft report submitted client; review and revisions
Week 18	Final Mitigation Report submitted to WisDOT.
Week 34	First follow up monitoring event (if required) roughly 4 months after confirmatory MASW survey.

5 Assumptions and Limitations

This proposed scope of work is based on the following assumptions and limitations:

1. The scope of work described in this letter describes investigation methods. Conditions identified by the investigation methods are expected to support specific mitigation measures. The recommendation of a mitigation approach will necessarily await the results of the investigation, as well as adequate, and review prior to the final recommendations being made by a Wisconsin-registered professional engineer. These recommendations will consider the investigation outcome to provide specific actions based on the conditions observed at each location.
2. Because field conditions can vary and new insights gained as a result of the investigation, additional geophysical methods may be used to augment the MASW data without limitation during the investigation. These may include modifications to the MASW method to add subsurface geophones in the storm sewer pipe, ground penetrating radar, electrical resistivity, or other methods.
3. This scope of work is focused only on the backfill above and adjacent to the storm sewer pipe. It is our understanding that corrections regarding the pipe joints and backfill below the spring line of the pipe will be addressed by others.
4. The proposed scope represents a reasonable standard of care to detect and mitigate potential low density areas or voids. This effort is subject to the limitations typical of any subsurface investigation. The scope allows for some uncertainty but do not guarantee that all anomalies will be detected or that future subsidence will not occur. Multiple factors may result in future subsidence that are beyond the scope of the investigation and proposed mitigation alternatives.
5. We assume that this investigation will occur prior to or in conjunction with corrective actions initiated by others on the storm sewer pipe joints. Final MASW will be conducted after joint sealing corrective actions have been completed.
6. For best results, the work should be conducted when water table conditions are at seasonally low levels.
7. Outcomes will be improved if the investigation occurs before or after surface frost migrates to a depth of greater than 3 feet below the ground surface. If extreme cold air temperature conditions persist, the investigation and mitigation efforts may need to be postponed. Surface level frost may alter the perceived soil density within the frozen ground.
8. For estimating purposes, we assume that weather-related days will not affect the cost or duration of field work. However, because of potential winter weather there is always a possibility that the project will be delayed. Heavy snow, rain, winds, and/or wind chill temperatures that drop below 10°F, or other conditions that prevent safe work from being undertaken, will cause delays that may add time to the schedule commensurate with the length of the delay.
9. Barr will select subcontractors it deems qualified for the investigation work at the time the project is authorized by your notice to proceed. We will provide you with their estimates for the scope of work requested. If you have insurance requirements for the subcontractors you agree to notify us in advance of your requested coverage, amounts, and need for insurance certificates.

10. IGE will be contracting the mitigation subcontractors per recommendations from Barr, and the work will be observed by Barr.
11. Multiple mobilizations will be required depending on contractor availability, weather and field conditions.
12. Downtime for subcontractors will be charged by their standard hourly rates. Field staff will conduct project work to the extent possible during downtime. Delays in the field will push back delivery of subsequent tasks, report preparation, and final deliverables.
13. The road will be closed to traffic and the full length of the pipe alignment will be accessible to contractor vehicles, equipment, personnel, drilling rigs, and ATVs.
14. We assume that IGE will provide an excavator and adequate trench boxes capable of allowing entry into a trench up to 12 feet deep for observation and materials testing.
15. No additional mitigation will be required as a result of the confirmatory MASW survey and confirmatory CPT investigation along the entire 3,300-foot length after mitigation is completed.
16. Barr is not responsible for verifying the completeness or accuracy of information provided by others.
17. Any pavement, curbs, or road features that are damaged or need to be removed as the project progresses will be repaired or replaced to their required conditions by IGE.
18. Barr's observations, opinions, and recommendations are based on the information available to us at the time of this letter. We recognize that additional data, field testing, design background information, and other considerations may exist but have not yet been incorporated into our considerations.
19. We would be pleased to review additional data should such information be made available to us, and if appropriate to revise our conclusions and recommendations if they are affected by the additional information. Please do not hesitate to contact us to discuss this matter further.

6 References

ASTM 2010, ASTM D 6938: Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth). ASTM International, Philadelphia, PA: American Society for Testing and Materials

ASTM 2015, ASTM D 1556: Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method. ASTM International, West Conshohocken, PA: American Society for Testing and Materials

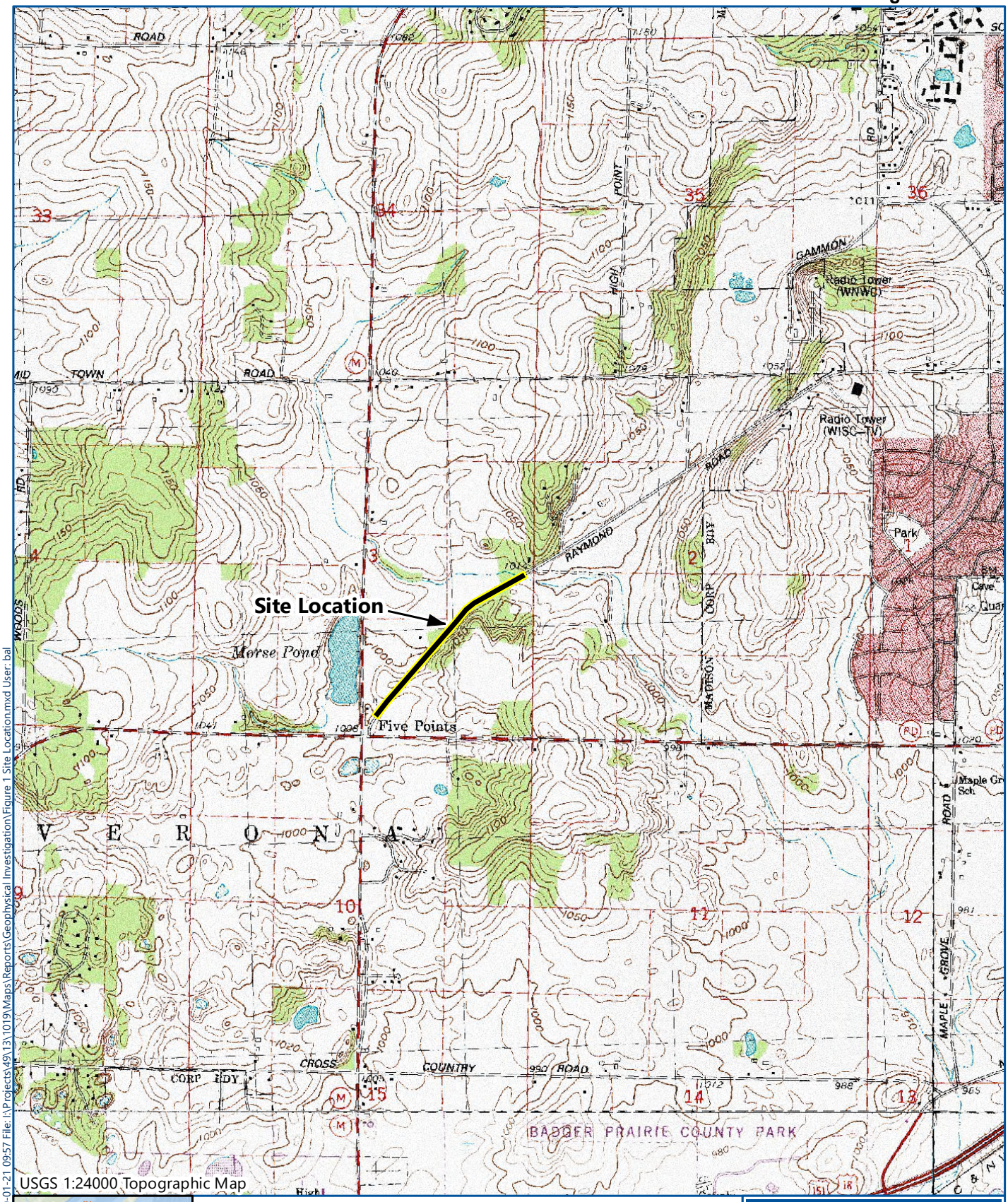
United States National Weather Service: Climatological Report (Annual) (2018, 2019). NWS Milwaukee/Sullivan, WI

ASTM 2012, ASTM D5778-12, Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils, ASTM International, West Conshohocken, PA: American Society for Testing and Materials

ASTM 2018, ASTM D1586, Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils, ASTM International, West Conshohocken, PA: American Society for Testing and Materials

ASTM 2012, ASTM D7764-12, Standard Practice for Pre-Installation Acceptance Testing of Vibrating Wire Piezometers, ASTM International, West Conshohocken, PA: American Society for Testing and Materials

ASTM 2012, ASTM D698-12e2, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)), ASTM International, West Conshohocken, PA, American Society for Testing and Materials





Stationing Alignment

0 1,000 2,000 3,000 4,000

Feet

SITE LOCATION
Raymond Road
Geophysical Investigation
Verona, Wisconsin

FIGURE 1

Barr Footer: ArcGIS 10.7.1, 2020-01-21 09:57 File: I:\Projects\49\13\1019\Maps\Reports\Geophysical Investigation\Figure 1 Site Location.mxd User: bal

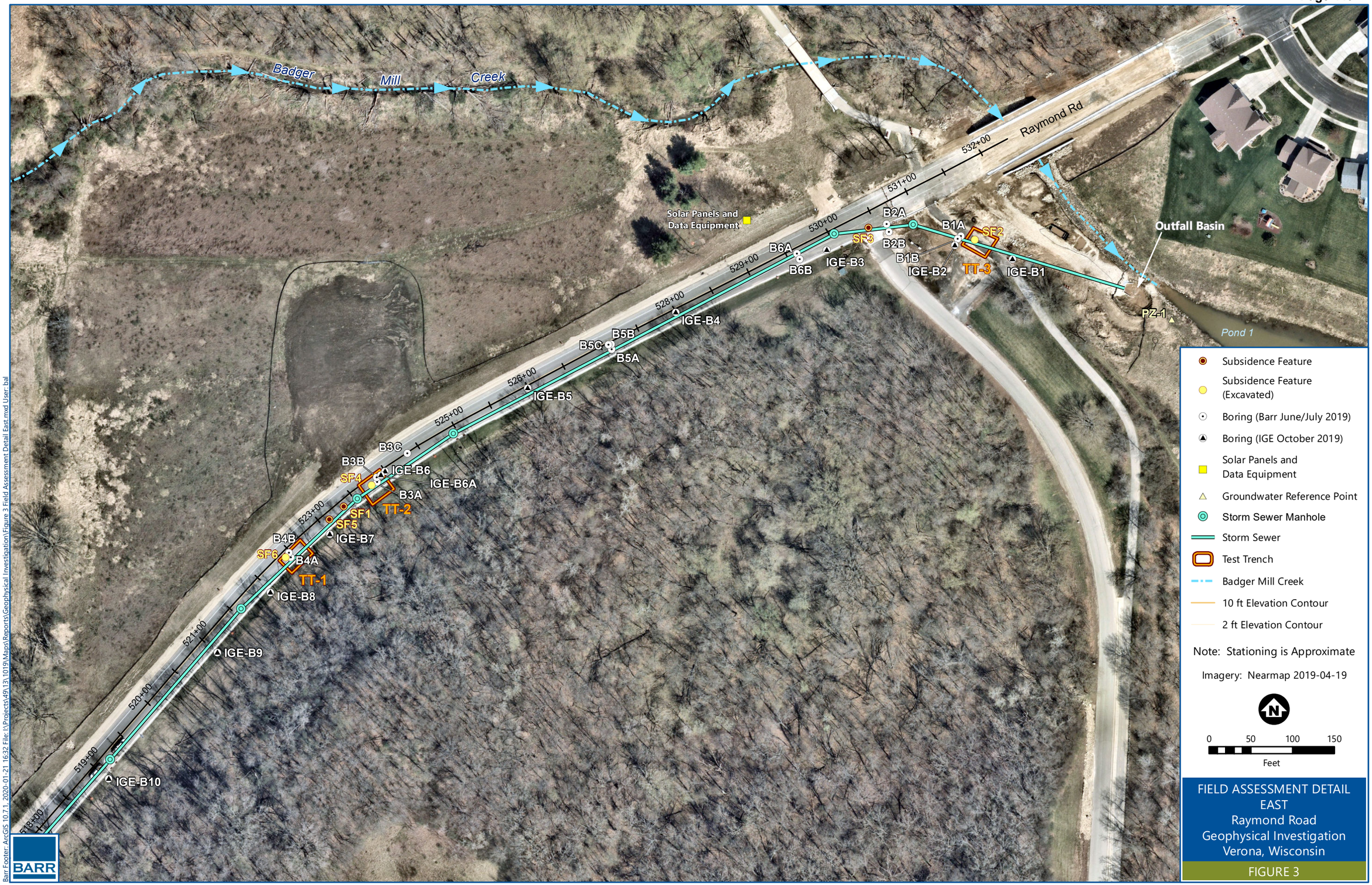


PROJECT AREA LOCATION
Raymond Road
Geophysical Investigation
Verona, Wisconsin

FIGURE 2

BARR

Barr Footer: ArcGIS 10.7.1, 2020-01-21 13:41 File: I:\Projects\49\113\1019\Maps\Reports\Geophysical Investigation\Figure 2 Project Area Location.mxd User: bal



FIELD ASSESSMENT DETAIL
EAST
Raymond Road
Geophysical Investigation
Verona, Wisconsin

FIGURE 3

BARR

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SF1
TT-2
SF5
IGE-B7
B4B
SF6
TT-1
B4A
IGE-B8
IGE-B9
IGE-B10
IGE-B11
IGE-B12
IGE-B13
IGE-B14
Raymond Rd
523+00
522+00
521+00
520+00
519+00
518+00
517+00
516+00
515+00
514+00
513+00
512+00
511+00
510+00
Subsidence Feature
Subsidence Feature (Excavated)
Boring (Barr June/July 2019)
Boring (IGE October 2019)
Storm Sewer Manhole
Storm Sewer
Test Trench
10 ft Elevation Contour
2 ft Elevation Contour
Imagery: Nearmap 2019-04-19
N
0
50
100
150
Feet
FIELD ASSESSMENT DETAIL
CENTRAL
Raymond Road Project
Verona, Wisconsin
FIGURE 4
BARR
Barr Footer: ArcGIS 10.7.1, 2020-01-21 13:12 File: I:\Projects\49\13\1019\Maps\Reports\Geophysical Investigation\Figure 4 Field Assessment Detail Central.mxd User: bal



Barr Footer: ArcGIS 10.7.1, 2020-01-21 13:37 File: I:\Projects\49\13\1019\Maps\Reports\Geophysical Investigation\Figure 5 Field Assessment Detail West.mxd User: bal

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engineering and environmental consultants

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Appendix A

Revised Responses to WisDOT Comments on Original Letter Work Plan Proposal

- Overall, more answers are needed before a comfort level can be established. This seems to be a proposal of work, not a plan this needed.
    - *The proposal is our work plan, but we are happy to provide this more detailed formatted work plan to address the additional information WisDOT requested.*
- Figure 3 is missing several Subsidence Feature Locations as compared to WisDOT documentation. Plan discuss five reported subsidence areas, but the provided Figure 3 indicates six locations. This needs to be clarified.
    - *{Figures 3-5} We hereby amend the plan to include the 6 locations shown on Figure 3. Our plan is to address all known subsidence features and complete a geophysical investigation to discover and remediate any additional subsurface areas of concern within the project footprint. If there are other features we are not aware of please note them on the map and they will be incorporated into the scope of work.*
- There are several areas of the provided plan that need further explanation and discussion
    - *We assume that this comment refers to the following content below.*
- Is the overburden mitigation supposed to happen before joints are fixed?
    - *{Section 4 & Section 5, assumption 5} No. It is not necessary to conduct mitigation before the joint repairs occur. Backfill mitigation will likely occur in conjunction with joint sealing.*
- Frozen ground? How does this affect what is being proposed*?*
    - *{Section 5, Assumption 7} Significant frost depths may favor use of an auger drill rig equipment rather than a Geoprobe to place grout for mitigation. The MASW geophysical investigation can be conducted over frozen ground. We have been told that the road surface above the subsidence features has been excavated and re-compacted. Therefore, the important stiffness anomalies should be below the frost penetration. Frost will change strength but the important layers should be frost free for accurate stiffness analysis. To the extent that frozen soils exhibit a need to be mitigated, that work would happen when frost conditions do not exist.*
- Will the 500 lb. hammer ruin the temporary asphalt driveway for the residents?
    - *{Section 5, Assumption 18} No. The hammer should not damage pavement. Patching or repair will be needed where borings are advanced through asphalt for ground truth or mitigation.*
- Will this equipment get between the sides of the pipe and the haunches? It seems like the pipe would prevent information in this area.
    - {Section 5, Assumption 3} *The equipment is placed on the surface above the pipe. It is possible that MASW will provide useful information about conditions adjacent to the sides and below the spring line of the pipe. This information will be shared with the Pipe Mitigation team. However, it is possible but not certain that we will be able to detect loose conditions in the backfill below the pipe by doing this type of survey. We assume that loose areas below the pipe will be addressed during the joint sealing effort.*

- More information about what the results could look like and what fix would happen for each result. That needs to be understood upfront.
    - *{Section 2.4.1 and Appendix B} In general MASW is very straightforward for use in this situation. It will show a profile of the backfill that will vary by showing intervals of higher or lower shear wave velocity. Because the rate at which sound waves travel through these materials is a function of the shear strength of those soils, high shear strength is correlated to higher velocity and lower soil shear strength indicates lower velocities. The fix for shallow areas will most likely be excavation and re-compaction. For deeper areas below about 3-7 feet, the presumptive remedy will be compaction grouting consisting of pressure grouting through a drill casing.*

    - *{Sections 3.6, 3.7} Areas of both high and low shear wave velocities will be included in the ground truth step to provide a correlation between wave velocity and soil stiffness. Areas that are correlated with low strength/velocity will be mitigated. The mitigation selected will depend on the factors at the depth/location where the apparent weak soils are discovered. The mitigation is intended to increase soil shear strength in the backfill regardless of whether a distinct void is observed.*
- The plan is not consistent with nomenclature. Several areas only highlight 'voids'. The Department is interested in mitigating both voids, and loosely backfilled zones. These zones may extend from the ground surface, to the haunch areas of the pipe. *{Section 5, assumption 3}*. We are assuming the pipe grouting will correct any loose/voided support areas below the pipe, and within the haunch areas
    - *{Section 2.4.1} Our plan is intended to identify and mitigate areas of low velocity shear wave features which we were referring to generically as low density soils or voids. The work plan has been updated to refer to loose soils as low density features. The wave velocity contrast identified as low surface wave velocity may represent a continuum of soil conditions ranging from dry loose sand, wet soft clay, loose backfill, and/or air and water filled voids.*
    - *We concur with the assumption that the Pipe Mitigation team is addressing low density soils below the spring line of the pipe (we avoided the term haunches as there seems to be some confusion as to what this term means.*
- The proposal indicates that only 1000' of the pipe trench has been compromised. What is the fix in this 1000' area that has been compromised? The Department feels the complete 3000' may be compromised, but distress may not have been exhibited in the upper 2000' of pipe yet, because it is buried deeper (has more cover). The contractor needs to prove to us that this area has no issues. This may require multiple MASW lines in the 2000' length.
    - *{Section 2.1} The plan is amended so that MASW will be conducted in 3 passes (transects) along the entire 3,300 foot centerline length of pipe as well as either side of the pipe.*

3.0 General - More explanation is needed in several areas, as detailed below.

- 3.0 Bullet 5. Proposal proposes a 'geophysical survey' for 2000' of the pipe. We assume this means MASW, but this is not specified.
    - *Correct; we propose MASW as the geophysical method of investigation.*
- 3.0 Bullet 6. More definition/explanation of potential mitigation actions need to be provided. (Discussed further in later comments.)
    - *Described below as noted.*

- 3.0 Last bullet. Some uncertainty of possible future issues is raised. We feel part of this proposal should include some type of monitoring program over time.
    - *{Section 3.7.4} Our final report will include recommendations for additional monitoring based on the results of the final verification resurvey. After the investigation and mitigation provides a thorough understanding of subsurface conditions informed decisions can be made when determining if a monitoring program is necessary. We have added a follow up MASW scan conducted approximately 4 months after the mitigation has been completed.*
- 4.0 As previously stated, MASW should be used to identify both voids and loose zones. Some parts of this section discuss voids only.
    - *{Section 2.4.1} Both terms can be interpreted to mean low velocity zones. We expect that both conditions are likely to coexist in areas below subsidence features and both are planned to be mitigated if observed.*
- 4.3 Will the MASW lines located at the outer pipe edges adequately provide coverage for the complete trench excavation width?
    - *{Section 3.4} Yes. We believe that the outside MASW lines alone are likely adequate to identify potential mitigation areas above the pipe both along its centerline as well as the edges. We have added the extra line along the pipe center as a quality control effort.*
- 4.3 Will MASW lines/data adequately delineate the material characteristics located in the zone from the top of the 'repaired' haunches, to the top of the pipe? Will the results from this area be 'masked' by the pipe?
    - *{Section 3.4} The MASW survey lines outside the centerline are intended to address the backfill conditions along the outermost edge (spring line) of the pipe and the overlying backfill. The pipe is a rigid 8 inch thick concrete material but at the same time, MASW may not resolve thin layers because the surface waves penetrating deeper areas are generally longer wavelengths. The longer wave lengths have lower resolution so they will not be blocked by the pipe. We propose conducting CPT borings to profile the deeper locations of the backfill to aid in interpretation of the deeper fill material from the MASW.*
- 4.4 Ground truth methods in this section include "direct push percussion rig", i.e. Geoprobe. We do not feel this is an appropriate device to effectively measure density/stiffness, as there is no quantitative test performed. This method was not included in the ground truth methods listed in Section 3.0.
    - *{Section 3.5} Our apology for any confusion,* although *Geoprobe has a CPT direct push tool that can be used with a percussion rig, it is still a CPT direct push method. We have not yet identified a Geoprobe contractor with this capability so we have deleted references to Geoprobe from the current work plan.*
- 4.5 More detail needs to be provided on the conceptual mitigative alternatives. CPT or Direct Push grouting is only for smaller, localized areas like voids. Is pressure grouting being proposed to address larger loose zones?
    - *{Section 3.7} These mitigation alternatives are conceptual at this stage because the MASW survey and ground truth step is needed to refine the scope of the mitigation. The plan indicates that in general, deeper and larger wide spread areas would be more effectively mitigated via grout injection.*
- The proposal does not address how existing facilities will be affected/addressed (i.e. curbs, utilities, storm/sanitary sewers, water lines, etc.). Vibratory compaction needs more explanation, as there are various methods, and some may not be applicable for this site. Vibratory compaction may not be possible/effective for larger, deeper zones.

  - *{Section 5, assumption 18} Vibratory compaction was dropped from the final work plan based on comments for WisDOT and concerns about damaging the pipe. We are not intending to mitigate any other utilities than the backfill above the storm sewer. However, any curbs or features that need to be removed will be replaced to their required conditions by IGE.*
- MASW, SPT, and CPT data used to locate areas with issues all need clarification on what values are acceptable before remediation is necessary. Each of these devices measure spectrums of stiffness/density, and there is no information provided on what 'acceptable limits' are. For instance, are SPT values of 8 acceptable, or are minimum values of 14 required? These criteria may also vary by soil type.
  - *{Section 1.1, 2.3, and 3.6} We have clarified our purpose and conceptual site model to more clearly define the objective of the investigation, which is to mitigate areas of loose soils potentially associated with future subsidence features. The goal is not to bring the entire backfill up to an arbitrary density or compaction threshold. Based on our conceptual model, the subsidence features are related to downward settlement of overlying soil into the loose zones. In shallow areas where we will have an excavation and can re-compact in lifts, we will meet compaction of 90% (95% in top three feet) standard proctor density.*
  - *For compaction pressure grouting performed at depths below 3-7 feet, we will be injecting grout into loose zones so that deformation and downward settlement cannot occur. In these areas, the key threshold is related to the volume of grout that the loose zone is able to take in. This will eliminate the potential for this zone to settle because the available pore space and deformable material will be compressed and occupied by the grout mixture. This process may require iterative trials and generally good engineering practice to evaluate field conditions and make corrections. The process will be documented in the final mitigation report along with challenges encountered and results of follow up monitoring and additional mitigation if required.*
  - *Performance standard. The confirmatory MASW survey, the addition of 4 month follow-up survey (with CPT data collection), should provide a high degree of confidence that potential subsidence features related to loose soils will be identified and corrected. These added tasks obviate the need for arbitrary threshold values because the monitoring and any follow up mitigation becomes what is essentially an outcome-based performance standard.*
  - *We have evaluated looking at blow counts or apparent density from CPT but our previous investigations indicated that the subsidence features were not well correlated with blow count data (i.e. high blow count n-values were found under subsidence features and low n-values found in areas with no subsidence). This suggests that the backfill is likely to exhibit variability that may not be directly reflected in an arbitrary threshold value, and would not be helpful in achieving the goal of limiting the formation of future subsidence features.*
- These decision points/values (required for each method) will greatly affect the amount of remediation work warranted. These decisions are also necessary to be able to analyze the confirmatory geophysical work. These decision points/values (required for each method) will greatly affect the amount of remediation work warranted. These decisions are also necessary to be able to analyze the confirmatory geophysical work.
  - *{Section 3.6} Upon review of the procedures and the additional monitoring proposed we do not believe that the paradigm described will apply to the reclamation work. Our proposal is to mitigate loose soils wherever they occur in the backfill above pipe. We will have indirect and direct data to determine where these areas are and will have sufficient post-mitigation monitoring to assess the performance of the mitigation. Because the basis for what does*

and does not require mitigation will be based on the geophysical data and ground-truth steps, specific quantitative thresholds may not be useful or achieve better outcomes.

- 6.0 Geoprobe use is again suggested. This does not appear to be a useful device for this work. (Unless only used for grouting.)
    - *{Section 2.4.2} CPT will be used and "direct push" alone will not be used to test soil density. As above, Geoprobe does have a CPT tool although it may be unlikely that Geoprobe will be useful when deep frozen soil conditions are present.*
- 7.0 Bullet 1. It is our understanding the pipe remediation plan also calls for haunch improvements between pipe joints. This contradicts what is written.
    - *{Section 5, assumption 3} The scope of work presented is for backfill above the storm sewer pipe; if there are apparent contradictions with other plans, we would need to understand the specific elements of those plans that are at issue in order to address this concern. After listening carefully to the proposed pipe mitigation plans, we are confident that there are no conflicts.*
- 7.0 Bullet 5. Surface frost is discussed, but there is no depth provided on what the unacceptable value is. This may affect project remediation schedule.
    - *{Section 5, assumption 7} We can work with some frost but mitigation will be slowed by more than 2 feet of frost due to difficulty in accessing the subsurface with drill rig. Work inside pipe (joint repair) will last into the summer 2020. If acceptable by WisDOT, we can complete the initial MASW and then complete ground truth and soil mitigation in the spring when frost is gone. With a follow up MASW after the pipe mitigation is completed.*
- 7.0 Bullet 14. It appears that Barr may not have all the collected-to-date information. Has everything been made available to them?
    - {Section 2.2} *IGE has informed us that the relevant project files have been provided to Barr Engineering and all data will be reviewed prior to commencement of the investigation to ensure project success.*
- More discussion/justification may be necessary on what remediation/investigations are performed first. Fix pipe joints and haunches before/after/concurrently with MASW work? MASW provides an assessment at one point in time. If pipe experiences more flow and soil loss after testing, the results may not be accurate anymore. This decision may also be related to the acceptable amount of surface frost during MASW testing.
    - *{Section 5, assumption 5} We propose conducting MASW first, followed by ground truth which can occur in conjunction with the pipe joint sealing. The joint sealing would be followed by backfill mitigation and then the confirmatory MASW survey.*
- Are MASW results affected by soil type?
    - *{Section 2.4.1} Yes. Surface wave velocity will vary somewhat by soil type but the method is most sensitive to changes in in shear strength. This is why MASW is uniquely useful for this investigation. The ground truth will help to further refine the limits of high vs lower soil strength/velocity.*

Review of 3D Geophysics (i.e. 3D) Proposal: There appears to be several disconnects between this proposal and Barr's proposed work. These include:

- 3D proposes 750' of survey during 'Phase 1', not 1000' as Barr proposes. But 3D includes 5000' in the cost estimate. These need to be clarified/corrected.
    - *The cost estimate will likely be revised to match payment terms but in all cases of apparent contradiction, the Barr scope shall prevail.*
- 3D discusses voids, but does not discuss defining looser zones, which is also required.

  - *They are the same condition from a geophysical standpoint regardless of terms.*
- 3D discusses depth to weathered bedrock. This has no relation to this project.
  - *Agreed this is an issue for some sites and is included as example in Appendix B of a dense material, but is unlikely at this site because we have at least one deep boring that suggests bedrock is much deeper than the pipe backfill.*
- 3D discusses collecting "tape measure data through the pipe". Further explanation on this is required.
  - *Correlation of the pipe distance to above ground distance will be provided by Barr Engineering based on our previous pipe inspection work.*
- 3D scope of work is confusing. Barr states there will be 5000 linear feet of MASW work, which agrees with the 3D "Primary Geophysical Survey" scope presented. Barr also states there will be 3000 lineal feet of post-remediation work completed, but 3D appears to indicate this is "Optional" (and it will be 5000'). 3D also appears to indicate that the "full length of the sewer line" investigation is only completed if "appropriate", and further states that repeat survey "could" be conducted. A definitive scope of work needs to be clarified, and coordinated between the two documents.
  - *Barr's scope of work prevails. 3DGeo will perform the work as directed. Units for payment by Barr's subcontractor is shown only to provide detail on the technical details of the survey.*

Appendix B

Multi-channel Analysis of Surface Waves (MASW)

MASW surveying is a non-invasive/ non-destructive imaging technique that uses surface seismic waves to calculate the Shear-Wave (S-wave) velocities of subsurface soils, sediments, and bedrock layers. S-Wave velocities are directly related to material strength (shear modulus and stiffness). The results of a MASW survey are shown as a layered earth model with S-wave velocities. It provides a 2D cross-sectional image of changes in strength vs. depth. MASW cross sections provide detailed information about the depth, structure and strength of subsurface materials from the near surface to depths of over 200 meters.

S-wave velocities vary for different subsurface materials based on changes in composition (mineralogy) and degree of compaction, and cementation. In general, very hard materials (e.g. bedrock) produce much faster velocities than unconsolidated sediments. Subsurface velocity variations make it possible for MASW surveys to map the interface (depth and topography) between different geologic layers, and to identify structural changes (such as fractures or loose zones) within those layers.

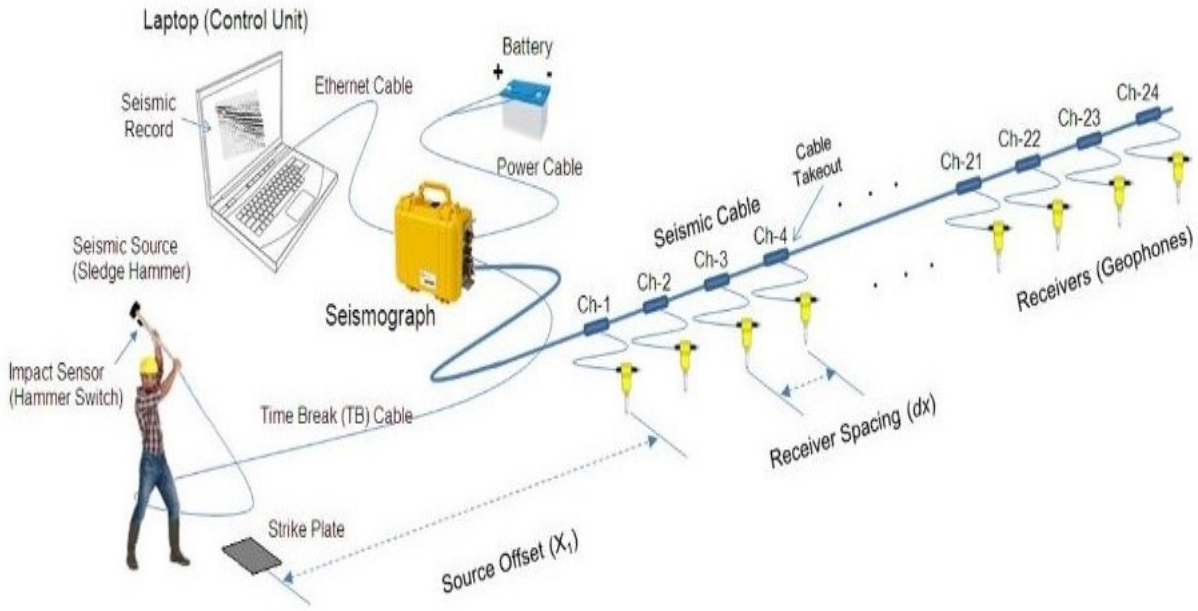


FIGURE 1: MASW data collection equipment

Figure 1 illustrates the data collection equipment used for a standard MASW survey. During a MASW survey surface waves are generated by impacting a seismic source such as a hammer on the ground surface. The surface waves are then recorded by an array of sensors (geophones) and a digital seismograph. Oftentimes the geophone array is affixed to a flexible towing cable called a "land streamer" to facilitate rapid deployment and movement of the array along pre-planned survey lines. A utility vehicle is used to pull the seismic source and land streamer across a survey area and along the survey lines at regular increments

(source stations). Source station interval, which typically ranges from 2 – 20 feet for most geotechnical and engineering applications, is the horizontal distance between MASW measurements along a survey line.

During MASW data processing each seismic record is analyzed using an FFT transform to isolate each component frequency from the field record and to calculate an accurate phase velocity for each frequency. This information is used to compile a dispersion curve for each source station along a survey line. The dispersion curves show the velocity of the surface waves as a function of frequency. Lower frequencies are larger waveforms and travel deeper in the earth than higher frequencies. The dispersion curve represents a unique profile in strength for each source point. Figure 2 shows a seismic field record with the extracted dispersion curve.

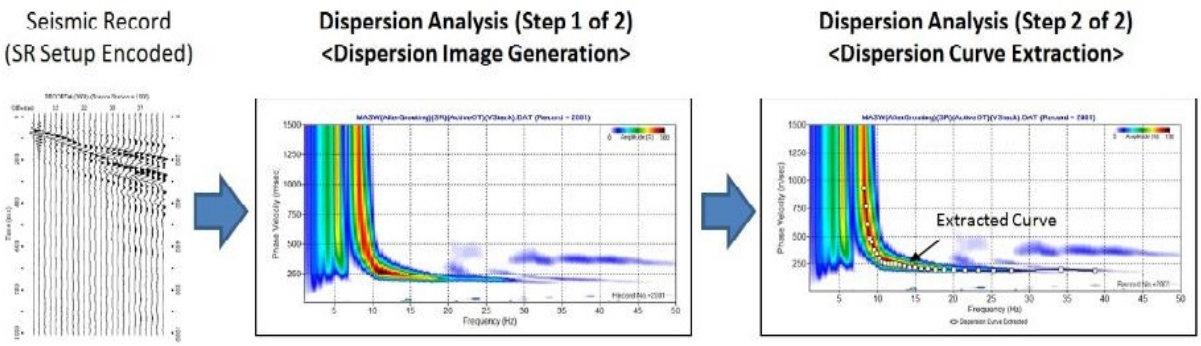


FIGURE 2: MASW field data and extracted dispersion result

After the dispersion curves are extracted an iterative inversion method is used to create one-dimensional S-wave versus depth profiles at each source station along a survey line. The 1D velocity profiles are individual sampling points, analogous to a soil boring, that are very closely spaced. At the completion of the MASW analysis the individual velocity vs. depth models along a survey line are combined and contoured to create a continuous two-dimensional S-wave velocity cross-section (Figure 3).

MASW cross sections display the changes in material shear strength beneath a survey line. Figure 3 shows a typical MASW cross section in which the measured S-wave velocities are color-coded. The structure of the subsurface sediment and rock layers, as well as the identification of anomalous strength zones can be interpreted from MASW cross sections. In the figure competent bedrock (red), weathered bedrock and fractures (yellow), sediment and soils (green), weathered or weak areas (blue), and potential void space (white) can be interpreted from the MASW data.

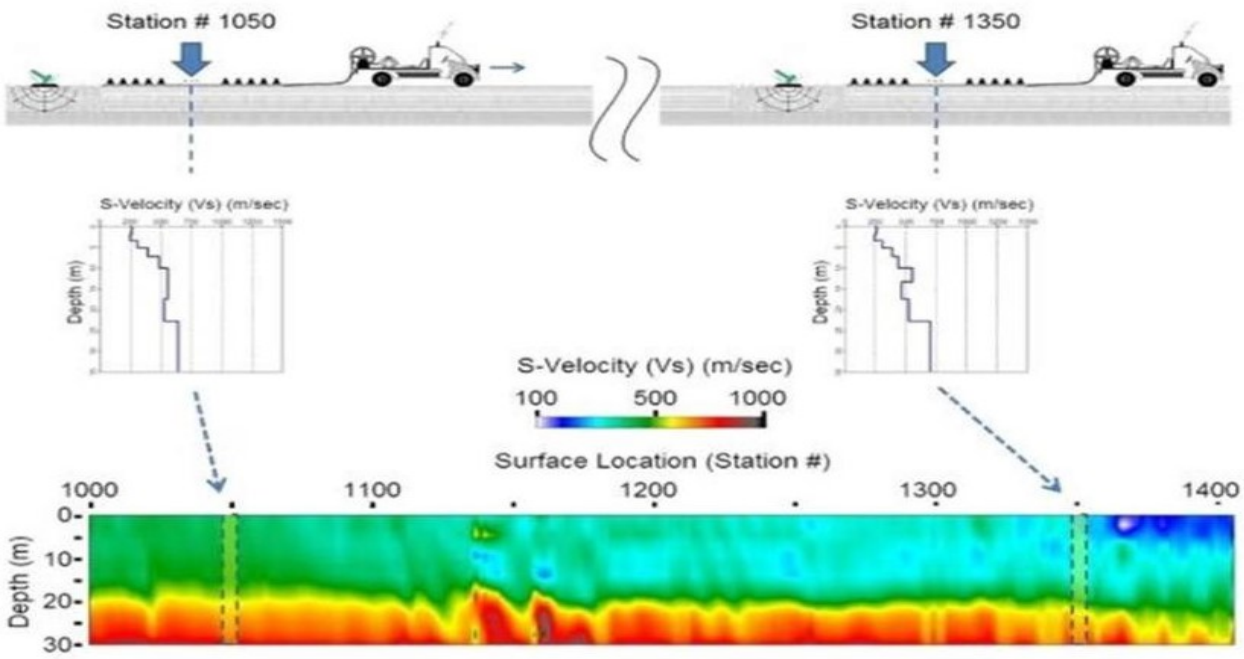


FIGURE 3: MASW 2D Cross Section

Unlike traditional seismic surveying, MASW benefits from the ease and speed of its data interpretation. Seismic reflection and refraction data processing requires experienced interpreters that analyze seismic waveforms that are oftentimes similar in character to the background noise in a dataset. This is a costly and time-consuming process that involves much human interaction. In contrast, the MASW method utilizes the highest energy, and most easily interpretable events on a seismic record, the surface waves ("ground roll"). MASW data processing uses automated software for the dispersion analysis and can provide results more quickly than traditional seismic methods.

MASW surveying has quickly been adopted as an important geotechnical tool. Because MASW data interpretation and collection are less complex and more efficient than other geophysical methods, it is now cost effective for engineers to get detailed subsurface strength information for a variety of geotechnical and environmental applications. With the ability to be rapidly performed as point samples (1D), along survey lines (2D), or across large areas (3D), MASW surveying is being utilized as a powerful site assessment tool.

Reference: Figures provided by Park Seismic LLC and MASW.com

resourceful. naturally.
engineering and environmental consultants

BARR

February 28, 2020

Mr. Dan Weinkauf
Integrated Grading & Excavating (IGE), Inc.
605 Grossman Drive
Schofield, WI 54476

Re: WisDOT Review Comments on the Work Plan for Investigation of the Backfill for the Raymond Road Project, Verona, WI

Dear Mr. Weinkauf:

Barr Engineering has reviewed the comments submitted by the Wisconsin Department of Transportation (WisDOT) in February 2020 regarding the Barr Engineering Updated Work Plan for Geophysical Investigation Oversight, and Evaluation of Mitigation Alternatives for Backfill, Raymond Road, Verona, WI dated January 22, 2020.

The Barr work plan specifies necessary initial investigation details required to collect the data necessary to establish thresholds for mitigation that has been requested by WisDOT. We believe that we have an obligation to first evaluate the in-situ soil conditions prior to proposing mitigation details including determinative thresholds.

The investigation will identify the specific intervals and locations that require mitigation. Therefore, moving forward with the MASW investigation and the ground truth appears to be the most reasonable path forward. We agree with WisDOT that an interim report summarizing the data and our recommended actions for mitigation of the backfill prior to mitigation are a reasonable path forward. We believe that an interim report summarizing the data and our specific recommendations on the backfill remediation targets can be submitted to IGE within 30 days of completion of the field work.

If you have additional questions please contact Jim Aiken at jaiken@barr.com or (952) 832-2740

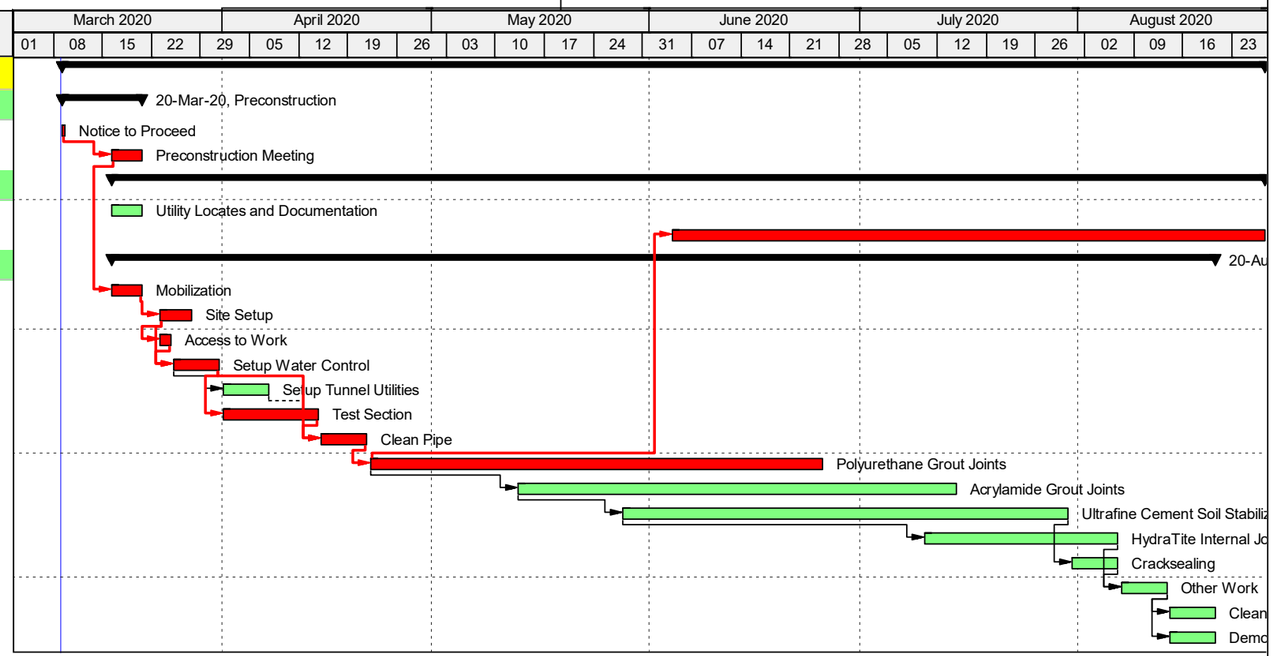
Sincerely,

James S. Aiken, PG
Wisconsin Professional Geologist #00317
Vice President

Elliptical Pipe Repair

05-Mar-20 15:22

Activity ID	Activity Name	Original Duration	Total Float	Activity % Complete	Start	Finish
Elliptical Pipe Repair		122	0		09-Mar-20	27-Aug-20
Preconstruction		10	0		09-Mar-20	20-Mar-20
A1210	Notice to Proceed	1	0	0%	09-Mar-20*	09-Mar-20
A1220	Preconstruction Meeting	5	0	0%	16-Mar-20*	20-Mar-20
Soil Above Pipe		117	0		16-Mar-20	27-Aug-20
A1000	Utility Locates and Documenta	5	112	0%	16-Mar-20*	20-Mar-20
A1020	Mitigation of Anomolies	60	0	0%	04-Jun-20	27-Aug-20
Pipe Repair		112	5		16-Mar-20	20-Aug-20
A1050	Mobilization	5	0	0%	16-Mar-20*	20-Mar-20
A1060	Site Setup	5	0	0%	23-Mar-20	27-Mar-20
A1070	Access to Work	2	0	0%	23-Mar-20	24-Mar-20
A1080	Setup Water Control	5	0	0%	25-Mar-20	31-Mar-20
A1090	Setup Tunnel Utilities	5	5	0%	01-Apr-20	07-Apr-20
A1200	Test Section	10	0	0%	01-Apr-20	14-Apr-20
A1100	Clean Pipe	5	0	0%	15-Apr-20	21-Apr-20
A1120	Polyurethane Grout Joints	46	0	0%	22-Apr-20	25-Jun-20
A1130	Acrylamide Grout Joints	43	5	0%	13-May-20	14-Jul-20
A1140	Ultrafine Cement Soil Stabiliza	45	5	0%	28-May-20	30-Jul-20
A1150	HydraTite Internal Joint Seals	20	5	0%	10-Jul-20	06-Aug-20
A1160	Cracksealing	5	5	0%	31-Jul-20	06-Aug-20
A1170	Other Work	5	5	0%	07-Aug-20	13-Aug-20
A1180	Clean-up / Reclamation	5	5	0%	14-Aug-20	20-Aug-20
A1190	Demobilization	5	5	0%	14-Aug-20	20-Aug-20



Remaining Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary

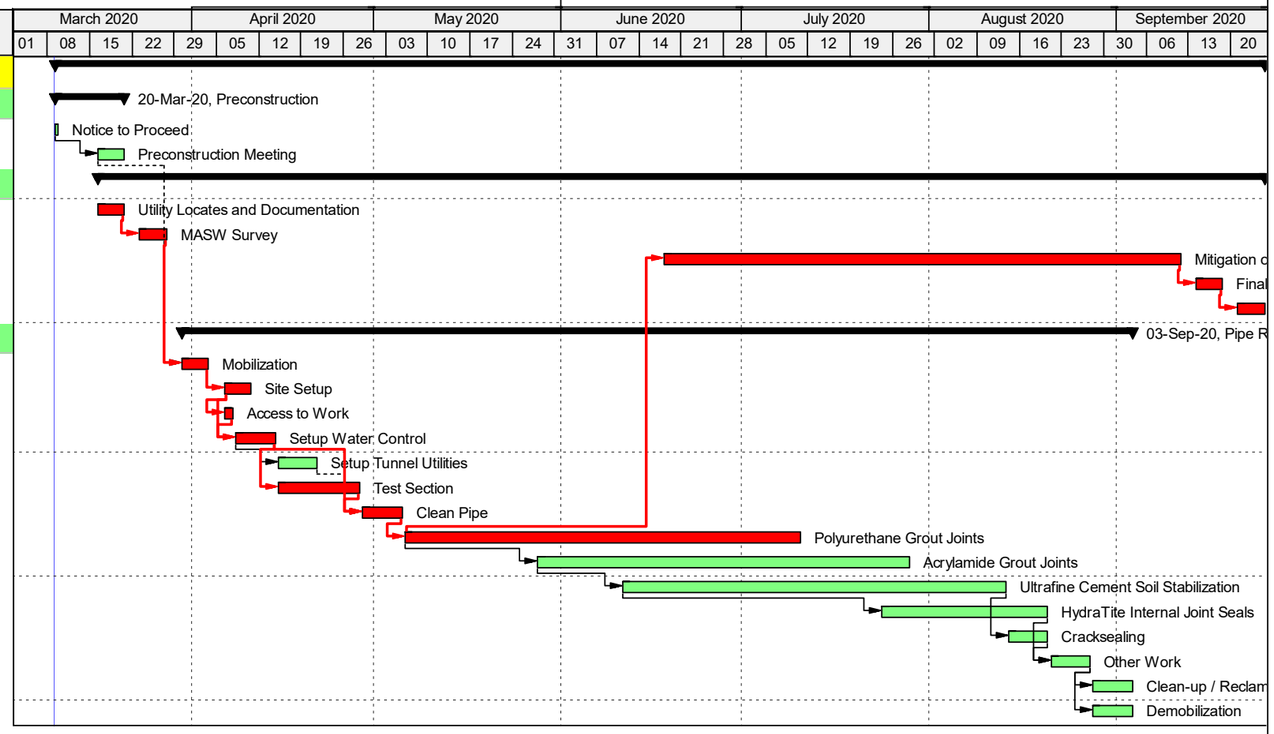
TASK filter: All Activities

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Elliptical Pipe Repair

05-Mar-20 15:26

Activity ID	Activity Name	Original Duration	Total Float	Activity % Complete	Start	Finish
Elliptical Pipe Repair		142	0		09-Mar-20	25-Sep-20
Preconstruction		10	10		09-Mar-20	20-Mar-20
A1210	Notice to Proceed	1	10	0%	09-Mar-20*	09-Mar-20
A1220	Preconstruction Meeting	5	10	0%	16-Mar-20*	20-Mar-20
Soil Above Pipe		137	0		16-Mar-20	25-Sep-20
A1000	Utility Locates and Documenta	5	0	0%	16-Mar-20*	20-Mar-20
A1240	MASW Survey	5	0	0%	23-Mar-20	27-Mar-20
A1020	Mitigation of Anomolies	60	0	0%	18-Jun-20	11-Sep-20
A1230	Final MASW Survey	5	0	0%	14-Sep-20	18-Sep-20
A1250	Final Report & Documents	5	0	0%	21-Sep-20	25-Sep-20
Pipe Repair		112	15		30-Mar-20	03-Sep-20
A1050	Mobilization	5	0	0%	30-Mar-20*	03-Apr-20
A1060	Site Setup	5	0	0%	06-Apr-20	10-Apr-20
A1070	Access to Work	2	0	0%	06-Apr-20	07-Apr-20
A1080	Setup Water Control	5	0	0%	08-Apr-20	14-Apr-20
A1090	Setup Tunnel Utilities	5	5	0%	15-Apr-20	21-Apr-20
A1200	Test Section	10	0	0%	15-Apr-20	28-Apr-20
A1100	Clean Pipe	5	0	0%	29-Apr-20	05-May-20
A1120	Polyurethane Grout Joints	46	0	0%	06-May-20	10-Jul-20
A1130	Acrylamide Grout Joints	43	15	0%	28-May-20	28-Jul-20
A1140	Ultrafine Cement Soil Stabiliz	45	15	0%	11-Jun-20	13-Aug-20
A1150	HydraTite Internal Joint Seals	20	15	0%	24-Jul-20	20-Aug-20
A1160	Cracksealing	5	15	0%	14-Aug-20	20-Aug-20
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A1180	Clean-up / Reclamation	5	15	0%	28-Aug-20	03-Sep-20
A1190	Demobilization	5	15	0%	28-Aug-20	03-Sep-20



Remaining Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary

TASK filter: All Activities

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