APPENDIX B

PART 5

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SPECIAL PROVISIONS FOR SEWER REHABILITATION

SECTION 500 - PIPELINE SYSTEM REHABILITATION

SECTION 500-1 - PIPELINE REHABILITATION

500-1.1 Requirements

500-1.1.1 General. This section covers the various pipeline system rehabilitation materials and methods.

The type(s) of rehabilitation materials and methods for a given project shall be designated on the Plans. The Agency may require testing of the materials and methods for compliance with these requirements prior to delivery to the job site and/or prior to acceptance depending upon the alternate selected. Materials shall be not more than six months old from date of manufacture at the time of installation. The intent of this Section is to provide various methods of pipeline rehabilitation as an alternate to replacement.

The specifications herein do not address the structural capacity of the rehabilitation systems described nor their structural requirements. All structural requirements as they pertain to each specific installation shall be approved by the Engineer in conformance with Subsection 2-5.3.

500-1.1.2 Submittals. All submittals required by these specifications but not limited to grouting annulus pertinent to some rehabilitation methods shall meet the requirements of the plans and Special Provisions.

500-1.1.3 Preliminary Inspection. The Contractor shall prior to the televising or rehabilitation of the pipeline, clean the entire line and remove all obstructions.

500-1.1.4 Television Inspection. Closed Circuit Television Inspection (CCTV) shall be required as both a pre and a post installation method to determine if the liner has been installed as required and that all laterals have been reconnected properly. Documentation consisting of a color video tape and written report detailing the condition of the main line and lateral openings shall be submitted to the Engineer for approval. If rejected, the Contractor shall be responsible for making all necessary repairs until the requirements are met.

500-1.1.5 Miscellaneous. The Contractor shall be responsible for locating all service connections and cleanouts. The Contractor shall provide notification of work activities to all local users and provide interim sewer service as necessary. Clean up and dust control shall meet the requirements of Subsection 7-8.

Whenever service reconnection is needed, the invert of the service connection shall match the bottom of the reinstated service opening. The service opening shall be reinstated to 100% ± 5% of the original service connection opening and the new edge shall be smooth and free of loose material.

500-1.1.6 Rejection. If the Contractor uses any material other than an approved material or an approved method, the Contractor shall, at its sole expense, remove the entire rehabilitated pipe and replace it with a new pipe as directed by the Engineer. All damaged rehabilitation materials shall be rejected and removed.

500-1.1.7 Measurement and Payment. Pipeline cleaning and inspection, including CCTV inspection, shall be paid for

at the contract unit price in the bid for pipeline cleaning and all inspection including CCTV. The unit price paid shall be considered full compensation for furnishing all labor, material, tools, equipment, apparatus, and incidentals for doing all the work required.

Pipeline point repair and rehabilitation shall be measured along the longitudinal axis between the ends of the pipeline as shown on the plans and shall not include the inside dimensions of structures.

The price per lineal foot or lump sum for point repair and rehabilitation shall be considered full compensation for furnishing and installing all fittings, connections, seals and special work shown on the plans, including all labor, materials and equipment required; the removal of interfering portions of existing sewers, storm drains and other improvements; the closing or removing of abandoned conduits and structures; the excavation of the trench and/or access pits, if required; the control of ground and surface waters; the preparation of subgrade; placing and joining of pipe; backfilling the trench and/or access pit; temporary and/or permanent resurfacing; and all other work necessary for point repair and rehabilitation, complete in place.

Notes to Specifier (NTS) - referenced to pertinent Section paragraphs:

500-1.1 The reference to testing followed up by the inspectors to ensure that pre-fabricated product are manufactured in accordance to the referenced Standards and these Standards. The products and materials that are developed on site should be tested in accordance to and meet the various strengths specified in these Standards.

500-1.2 Pipeline Point Repair

500-1.2.1 General. This section specifies point repair of existing sewers prior to rehabilitation. The Contractor shall be responsible for repairing the sewer where point repairs are identified on the plans or the special provisions. If this is not shown, it will constitute extra work when approved by the Engineer.

The work shall include verifying the location of the spot repair through CCTV or man-entry inspection of the sewer, locating all interfering utilities, furnishing all labor and materials necessary for, but not limited to excavation, dewatering, pipe repair or replacement, backfill, surface restoration, temporary flow bypassing, sewer dewatering and traffic control.

500-1.2.2 Materials. The pipe and repair materials shall be the same as the existing line unless otherwise indicated and shall comply with Section 207 for type and class required.

500-1.2.3 Excavation. All trenching and excavation shall conform to Section 306.

500-1.2.4 Sewer Bypassing and Dewatering. When required by the Contract Documents or the process, the Contractor shall bypass sewer flow around the work and dewater the work area, all in conformance with Subsections 7-8.4 and 306-3.3.

500-1.2.5 Notification of Work. The Contractor shall notify the Engineer not less that 48 hours in advance of the planned time to begin point repair work at a particular location.

500-1.2.6 Installation and Field Inspection. The installation of the replacement pipe and/or repair work shall conform to requirements of Section 306. All point repairs shall be

inspected and measured by the Engineer prior to any backfilling and compaction.

NTS - referenced to pertinent Section paragraphs:

500-1.2.2 The repair pipe should be of the same type removed for ease of connection, unless prevailing reasons dictate otherwise.

500-1.2.3 The length of excavation is normally 5 to 10 feet beyond the pipe to be replaced. This facilitates an easier closure.

500-1.2.4 Sewer Bypassing. The current "state of the art" on bypassing permit diverting flows up to 100 million gallons per day, without any spillage.

Specific Operations. The Contractor should be encouraged to accomplish any television or grouting work during the low flow periods of the day. This may still require plugging the pipeline to the level of preventing upstream surcharging. The sliplining utilizing jointed liner pipes normally will not cause upstream surcharging. When the flows in the pipeline exceed one half the pipe diameter, the sliplining operation becomes very difficult. The work is usually halted at that point, therefore, upstream surcharging is generally not a problem. The use of solid wall HDPE will usually require some bypassing unless the work is conducted during low flow conditions.

Standby Equipment. The "Rain for Rent" bypass Contractor normally has one or two standby gas operated pumps available for emergency use.

500-1.3 High Density Polyethylene Liner Pipe. (Solid Wall)

500-1.3.1 General. High Density Polyethylene Solid Wall liner pipe

for use in sanitary sewers, storm drains and house connection sewers, shall comply with ASTM D-3350 or ASTM F-714. Unless otherwise indicated, liner for pipe shall conform to SDR 32.5. Fittings shall comply with ASTM D-2683 or D-3261. Fittings fabricated by mitered butt fusions are also permitted. The standard dimensional ratios (SDR) shall conform to the following table:

Standard Allowable Feet * (Groundwater above invert)	Standard Dimensional Ratio (SDR)	Maximum for ungrouted installation
	32.5	
4.5		
	26	
9.0		
	21	16.0
	19	23.0
	17	
30		
	15.5	
44.0		

* Safety factor not included

500-1.3.2 Material Composition. Pipe and fittings shall be made from HDPE resins complying with ASTM D-1248, Type III, Class C, Category 5, Grade P34, and ASTM D-3350, and shall also meet the requirements of Subsection 207-19.2.

500-1.3.3 Liner Pipe Acceptance. Liner pipe acceptance shall conform to Subsection 207-19.3.

500-1.3.4 Marking. Liner pipe marking shall conform to Subsection 207-19.4.

500-1.3.5 Chemical Resistance and Physical Testing. HDPE pipe furnished under this Subsection shall conform to Subsection 207-19.5.

500-1.3.6 Installation and Field Inspection. The HDPE Liner Pipe shall be in accordance to ASTM F-585, regarding inspection and cleaning the existing pipeline, preparation of entry points as needed, and the storage, handling, joining and lining of polyethylene pipe. A proofing pig shall be pulled through the existing pipeline, prior to liner insertion to verify adequate clearances.

500-1.3.7 Grouting Annular Space. The entire annular space between the outside of the liner and the inside of the existing pipe shall be grouted. Grouting of the annular space shall be done in such a manner as to prevent damage or collapse of the liner. Grout shall be pumped into the annular space at the manholes, service connections and wherever the liner is exposed. Grout shall be a portland cement and/or fly ash-Behntonite Gel mixture with any other filler passing a No. 140 Mesh. Disparants can be added to lower the viscosity for increased pumpability. The grout shall have a heat of hydration of 140^{o}F maximum and a minimum compressive strength of 300 psi in 28 days. The grout shall also have a maximum of 2 percent free water and a U.S. Corps of Engineer's flow cone test of 15 to 80 seconds. The grout mix and placement procedure shall be submitted to the Engineer for approval at least 72 hours prior to use.

When the annular space is less than 1 inch, grouting is not required and the liner pipe shall have an SDR of 26, minimum. The liner pipe shall be sealed in both directions at the manholes to a depth of 12 inches minimum. Service connections shall be sealed to a depth of 12 inches minimum each way and encased in concrete.

500-1.3.8 Service Connections. The Contractor shall be responsible for locating all service laterals and cleanouts. Service connections shall not be made until the liner pipe has stabilized, which is normally accomplished after a 24-hour waiting period. Service laterals shall be connected to the liner pipe by use of a heat fused saddle or mechanical saddle as approved by the Engineer.

NTS - referenced to pertinent Section paragraphs:

500-1.3.1 General. The following table lists commercially available liner sizes and DR values, per ASTM F-714. The specifier should verify that the liner will provide sufficient flow capacity and withstand hydrostatic loads shown in "Maximum Allowable Feet" table given in Subsection 3.1, utilizing a Safety Factor of 2. The liner wall thickness is determined by dividing the liner outside diameter by the DR value.

Existing Sewer inside values diameter inches	**Available liner outside diameter inches**	**Wall Thickness at various DR**					
		32.5	**26.0**	**21.0**	**17.0**	**15.5**	**11.0**
4	3.500	0.108	.135	.167	.206	.226	0.318
6	4.500	.138	.175	.214	.265	.290	.409
6	5.563	.171	.214	.265	.327	.359	.506
8	6.625	.204	.255	.315	.390	.427	.602
8	7.125	.220	.274	.340	.420	na	na
10	8.625	.265	.332	.411	.507	.556	.784
12	10.750	.331	.413	.512	.632	.694	.977
15	12.750	.392	.490	.607	.750	.823	1.159
15	13.386	.412	.515	.638	.788	na	na

15	14.000	.431	.538	.667	.824	.903	1.273
18	16.000	.492	.615	.762	.914	1.032	1.455
21	18.000	.554	.692	.857	1.059	1.161	1.636
21	20.000	.615	.769	.952	1.176	1.290	1.818
24	21.50	.662	.827	1.024	na	1.387	1.955
24	22.00	.677	.846	1.048	1.294	1.419	2.000

In general, DR values of 32.5 and 26 will be used for gravity and low-pressure systems, such as sewers, sewer force mains, intakes and outfalls. Lower DR values, i.e., greater wall thickness is used for medium and high pressure systems and may be warranted for gravity work where the existing parent pipe material is missing.

Several plastic pipe manufacturers contend that the Manning flow characteristic "n" has a value of 0.009. This has been substantiated when transporting clean water but has not been substantiated for long term sanitary sewage flows.

500-1.3.2 Material Composition. In most cases, the PE manufacturer will be Phillips through a distributer so the physical properties will be according to ASTM Standards. Some manufacturers have not submitted samples for chemical testing according to Subsection 500-1.3.5. The use of acceptable pipe must be confirmed through the City Lab.

500-1.3.6 In areas, e.g., jacking pit, where two directional pull is accomplished, a closure is required. This closure can be accomplished by utilizing a stainless steel gasketed coupling. The coupling dimension for pipe joining is listed below:

Outside diameter of the liner pipe (inches)*	Minimum length of coupling (inches)
10	5.563
15	7.125
15	8.625
20	10.750
20	13.386
30	16.000

* National Association of Sewer Service Companies (NASSCO) Recommendation.

The Contractor having cleaned, inspected, and proofed the sewer has ample opportunity to request spot repairs and correct any conditions which may prohibit liner insertion. Nevertheless, the Contractor may still be unable to successfully pull the liner through the existing sewer without experiencing maximum pulling forces. In most cases, this will be due to Contractor negligence, such as leaving rocks or debris in the pipeline which binds the liner, or assuming certain defects, such as sags or offset joints will not present a problem. Other cases may warrant payment by the City for additional access pits and/or point repair where the sewer has these defects.

500-1.3.7 Annular grouting has been a subject of considerable debate. Most of the pipe suppliers contend that grouting the annulus is unnecessary. They normally recommend that

only immediate upstream and downstream of manholes or structures be grouted for preventing infiltration.

The practice of grouting the annulus when one-inch or more space is available is recommended for the following reasons:

1. Provides structural rehabilitation
2. Prevents liner from deflecting
3. Prevents liner from collapsing
4. Prevents long term infiltration
5. Prevents liner from moving
6. Locks in service connections
7. Eliminates concrete blocking of service connections
8. Better than sealing at manholes
9. Extends life from uncertain to 50 years or more
10. Provides protection to liner when cleaning
11. Resists temperature changes

It is impractical to grout the annulus when less than one-inch space is available. Normal practice is to design the slipliner with the next available thicker walled DR.

500-1.4 Cured-In-Place Liner Pipe (CIPLP)

500-1.4.1 General - The placement of an approved epoxy resin-impregnated flexible tube shall be installed into an existing conduit by utilizing a hydrostatic head. When specified, this system may be used in sanitary sewers, storm drains and house connection sewers. The initial stiffness factor shall conform to the following table.

Nominal Diameter inches (I.D. of Orig. Pipe) above invert	**Stiffness Factor EI (in^3 - lbf/in^2)**	**Maximum Allowable Feet* Groundwater**
6	328	238

8	328	96
10	328	48
12	328	27
12	1109	96
15	1109	48
18	1109	27
18	2628	67
21	2628	41
21	5160	92
24	2628	27
24	5160	54

* Safety factor not included

Note No. 1 Stiffness Factor shall be determined in accordance with ASTM D-2412.

Note No. 2 Safety factor not included.

Note No. 3 Maximum allowable groundwater loads for partially deteriorated pipes. Where groundwater is higher, see Plans or Specifications.

Note No. 4 For ID's larger that 24-inch, see Plans or Specifications.

Note No. 5 The Stiffness Factors listed in the table are initial values for gravity flow condition. For Pressure Applications, the Stiffness Factors are usually larger.

500-1.4.2 Material Composition and Testing. The tube shall consist of one or more layers of flexible needled felt or an equivalent woven and/or non-woven material capable of carrying resin, withstanding installation pressures and curing temperatures, and compatible with the resin system used. The resin used shall be compatible with the

inversion process, and be able to cure in the presence or absence of water. The initiation temperature for cure shall be as recommended by the resin manufacturer and approved by the Engineer. The cured-in-place-liner-pipe shall have as a minimum the following initial and long term structural properties for use as a liner and not as a structurally designed pipe for direct burial:

PROPERTY	TEST METHOD	INITIAL	LONG TERM
Flexural Strength	ASTM D790	5,000 psi	------
Flexural Modulus	ASTM D790 and ASTM D2990	300,000 psi	150,000
Tensile Strength	ASTM D638	4,000 psi	------
Tensile Modulus	ASTM D638	250,000 psi	125,000

Note: Initial values are defined in ASTM D-638 and D-790. Long Term Value is defined as 50 years and is determined by ASTM D-2990 Test Method.

The Engineer may, at any time prior to installation, direct the Contractor to obtain cured samples and test them in accordance with the listed ASTM standards for determining and meeting properties.

500-1.4.3 Tube Acceptance. At the time of resin impregnation each lot shall be inspected for defects. The resin shall not contain fillers, except those required for viscosity control, fire retardant, or extension of the pot life. Thixotropic agents which will not interfere with visual inspection may be added for viscosity control. Also, the opaqueness of the plastic coating shall not interfere with visual inspection. Resins may contain pigments, dyes, or colors which do not interfere with visual inspection of the cured-in-place-liner-pipe or its required properties. Additives may be incorporated that enhance the physical and chemical resistant features.

For testing purposes, a lot shall consist of all the tube for a given rehabilitation run.

500-1.4.4 Chemical Resistance. The cured-in-place-liner-pipe epoxy resin system furnished shall meet the corrosion-weight change requirements of Subsection 210-2.3.3. Proof of meeting these requirements shall be provided to the Engineer for his approval, at least 15 days prior to commencement of work.

500-1.4.5 Resin-Impregnated Tube Installation Procedure. Prior to tube placement the Contractor shall, in accordance with Subsection 2-5.3, submit shop drawings of construction details. The shop drawings shall include the location and method of placement and by-passing location with sufficient detail to assure that the work can be accomplished without sewage spill.

The OD of the tube being inverted shall be sized correctly allowing for stretch to fill the existing pipe completely. The existing pipe shall be cleaned of any obstructions or debris prior to tube inversion and shall be approved by the Engineer. The existing pipeline shall be monitored by use of a closed circuit television camera. The Contractor shall protect the manholes to withstand forces generated by equipment, water or air pressures used while inverting the tube.

500-1.4.6 Installation. The epoxy resin saturated tube shall be inserted through an existing manhole or other approved access by means of the installation process and the application of a hydrostatic head sufficient to fully extend it to the next designated manhole or termination point. The placement procedure shall be required to produce dimples at the service connections.

500-1.4.7 Curing. After placement is completed a suitable heat source and distribution equipment shall be required to distribute or recirculate hot water throughout the pipe.

Temperature shall be maintained during the curing period as recommended by the resin manufacturer, and approved by the Engineer. After the tube is cured, a cool-down period shall be used prior to opening the downstream stopper, connecting of services and returning normal flow back into the system.

500-1.4.8 Service Connections. After the curing is complete and the pipe system is placed into service, existing service connections shall be re-established. This may be done without excavation by means of a remote control cutting device operating within small diameter pipe or directly for man entry pipe. A CCTV camera shall be attached to the cutting device for precise location of service connections and inspection of the finished cured-in-place-liner-pipe.

NTS - reference to pertinent Section paragraphs:

500-1.4.1 General. The unit cost of cured-in-place-pipe (CIPP or Insituform) can be high and at times compares to pipe replacement costs. On projects that are small, or present difficult site conditions, unit application costs may approach $20 to $30 per inch diameter per linear foot. On large projects where inversion lining is bid as an alternate to replacement, the unit cost is typically in the range of $6 to $9 per inch diameter per linear foot.

Inversion lining has been performed on pipes ranging from 4-inches to 108-inches in diameter. The design DR is typically 50 maximum and it can be designed to produce a pipe stiffness over 46 psi, when measured to ASTM D-2412.

The four and six inch sizes are normally for service laterals. The technology is rapidly improving, but six inch size mainlines havings service connections are difficult to connect without excavation.

500-1.4.2 Material Composition and Testing. The liner design is provided in Appendix A. The liner performance, i.e. strengths and corrosion resistance are intimately related to the resin employed. Several factors affecting the liner design are as follows:

1. A specific epoxy resin has been tested and meets the corrosion resistance requirements of Subsection 210-2.3.3.

2. The required buckling strength of the liner will depend on the condition and configuration of the existing pipe, external hydrostatic head, soil types, cover depth and traffic loadings. Reference should be made to the various formulae and sample calculations provided in Appendix A.

3. The existence of groundwater and/or temperature of the soil will affect cure time.

4. The epoxy type resin may bond somewhat to the existing pipe. This can enhance its overall strength in that the various formulae used assume negligible bonding. It is common practice to use epoxy resin for pressure pipe and service lateral rehabilitation.

500-1.4.6 Inversion. The entire process can be performed without excavation and therefore is applicable where open-cut construction is undesirable. The liner is fabricated to correct pipe perimeter allowing for stretch. The liner is precut to the desired length and one end is sealed permitting total inversion. In most cases, the resin added in the Contractors shop is under controlled conditions. The liner is then packed in ice and transported to the construction site in a temperature controlled truck.

500-1.4.7 Curing. Despite the claims from the resin suppliers, INA and the installation Contractors, the ultimate permanence of the inversion liner can only be gaged overtime. The

process is less than 20 years old and projection for a 50-year life or greater are unproven. Therefore, to establish that the minimum initial strength requirements are being met, testing of the finished liner is recommended.

500-1.5 PVC Sewer Lining System

500-1.5.1 General. Polyvinyl Chloride extrusions with annulus grouting shall be installed for use in sanitary sewers, storm drains and house connection sewers. This applies to the rehabilitation of small diameter pipe and man-entry pipe in terms of materials and installations.

500-1.5.2 Material Composition. Materials shall conform to Subsection 207-17.2.

500-1.5.3 Material and Equipment Acceptance. At the time of manufacture each lot of plastic strips shall be inspected by the manufacturer for defects, and the physical properties certified in accordance to the ASTM Standards listed in this Subsection, or as indicated in the Specifications. The minimum thickness of the plastic strips and panels shall be as follows:

Nominal Diameter inches	**Minimum Thickness Former Strip inches**	**Minimum Joiner strip inches**	**Profile Height I.D. of Orig. Pipe inches**
8 to 12	0.025	0.025	0.192

15 TO 18	0.030	0.031	0.242
24 to 36	0.045	0.058	0.480
30 to 72*	0.060		0.488

* Material dimensional information for the man-entry placement.

The initial stiffness factor shall conform to the following table:

Nominal Diameter inches (I.D. of Orig. Pipe) above invert	**Stiffness Factor EI (in^3 - lbf/in^2)**	**Maximum Allowable Feet* Groundwater**
8	120	228
10	120	117
10	240	233
12	240	136
15	240	73
15	600	184
18	600	90
24	600	34
24	1600	94
30	1600	50
36	1600	27

For ID's larger than 36 inches, see Plans or Specifications

1. Stiffness factors shall be determined in accordance with ASTM D-2412.

2. Safety factor not included. Grout support factor is included.

At the time of delivery, the strips shall be homogeneous throughout, uniform in color, free of cracks, holes, foreign materials, blisters, or deleterious faults. For testing purposes, a production lot shall consist of all strips produced during any work shift and must be identified as opposed to previous or ensuing production. The Contractor shall furnish and maintain, in good condition, all necessary equipment as required for the proper execution and inspection of the work.

500-1.5.4 Marking. Each PVC continuous strip on each reel shall be distinctively marked on its inside surface end with a coded number which identifies the manufacturer, strip thickness, minimum profile height, size, material, machine, date and shift on which the material was extruded. These markings shall also appear on the PVC strips at a maximum distance between markings of five (5) feet, and shall be visible from inside the completed liner.

500-1.5.5 Chemical Resistance. The PVC and cured sealant/adhesive material furnished under this Subsection shall conform to the corrosion weight change requirements of Subsection 210-2.3.3 chemical solutions at listed concentrations. Proof of meeting these requirements shall be provided to the Engineer for his approval at least 15 days prior to commencement of work.

500-1.5.6 Installation and Field Inspection. The existing pipeline shall be cleaned of any obstructions and televised. The condition shall be approved by the Engineer prior to insertion of the liner. The plastic strips or panels shall be handled with care to ensure that the plastic is

not kinked, gouged or otherwise damaged.
The former and joiner strips shall be engaged and an approved sealant/adhesive shall be injected onto the engaged locks. The Contractor shall ensure that the joiner strip is continuously engaged.

For man-entry pipe, the PVC panels shall be cut and trimmed to fit as near as practical to the internal perimeter of the existing conduit. A bead of approved sealant/adhesive shall be applied to the female locking edge of the former strip. End joins shall be made with the plasticized end sections, which shall overlap the joint by not less than 4 inches. End joins shall be staggered and shall remain below the normal flowline of the sewer.

500-1.5.7 Grouting Annular Space. For small diameter pipe, the annular space between the outside of the liner and the inside the existing pipe shall be grouted. Grouting of the annular space shall be done in such a manner as to prevent damage or collapse of the liner. Grout shall be pumped into the annular space at manholes, service connections and wherever the liner is exposed.

Grout shall conform to Subsection 500-1.3.7.

For man-entry pipe, the grout shall be injected behind the liner by tubes placed on top of the liner or holes drilled through the liner. Any holes in the plastic shall be covered with a patch of similar material as approved by the Engineer.

500-1.5.8 Service Connections. Service laterals connections shall be re-established with the liner in accordance with manufacturers recommendations as approved by the Engineer.

NTS - referenced to pertinent Section paragraphs:

500-1.5.3 & 1.5.7 Annular grouting is done after the strips and/or panels are placed. The permissible groundwater loadings are determined assuming that the upper 25% of the space is ungrouted. It is desirable to attain 100% annular grouting but it is not absolutely necessary. Full grouting on man-entry applications can be readily attained.

500-1.5.8 Service laterals shall be reinstated by excavation and reconnected by use of a saddle after the existing pipe is broken, providing ample working space.

500-1.6 Thermal Reduction Liner Process

500-1.6.1 General. Shall conform to 500-1.3.1

500-1.6.2 Material Composition. Shall conform to 500-1.3.2

500-1.6.3 Liner Pipe Acceptance. Shall conform to 500-1.3.3

500-1.6.4 Marking. Shall conform to 500-1.3.4

500-1.6.5 Chemical Resistance and Physical Testing. Shall conform to 500-1.3.5, except the various requirements shall be met with samples from pipe that has experienced the Thermal Reduction Process.

500-1.6.6 Installation and Field Inspection. The HDPE Liner Pipe work shall be in accordance to ASTM F-585, regarding inspection and cleaning the existing pipeline, preparation of entry points as needed, and the storage, handling and joining of polyethylene pipe. The existing pipeline shall be monitored by use of a closed circuit television camera before commencing liner work and again after it is completed. A proofing mandrel shall be pulled through the existing pipeline, removing protruding laterals, etc., prior to liner insertion. The pipeline shall also be mandrelled after the liner has stabilized.

The HDPE pipe will be inserted through the heating element with controlled tension for pulling the liner through the existing pipeline. On reaching the exit

point, the pipe should be pulled beyond this point as advised by the coordinator at the entrance point. The allowance shall be made on length predicated on the thermal and tension levels developed during the pull. The stretching will be recovered over a period of time depending upon temperature levels above the ambient condition. When stabilization is complete, the HDPE pipe should be anchored into the existing pipeline, producing negligible annular space.

500-1.6.7 Service Connections. After stabilization is complete, and the pipe is placed into service, the existing service connection shall be reconnected. This may be done without excavation by means of a remote control cutting device operating within the pipeline. A television camera and a precise locating device shall be attached to the cutting device for the location of service connections and inspection of the finished HDPE pipe as approved by the Engineer.

NTS - referenced to pertinent Section paragraphs:

500-1.6.1 The Thermal Reduction Process (Swagelining) has been used successfully, however, very limited for sanitary sewer rehabilitation. If it ceases to be viable, it will probably be withdrawn from the 1994 Greenbook.

500-1.6.6 Total bypass must be maintained throughout the work. Service laterals within the area of work must be maintained until reconnected to the newly installed HDPE pipeline.

500-1.7 Deformed HDPE Sewer Rehabilitation System

500-1.7.1 General. Folded High Density Polyethylene (HDPE) extrusions introduced into sanitary sewers and storm drains in order to rehabilitate the existing pipeline system without excavation. This method applies to the rehabilitation of 4" thru 16" diameter pipe in terms of

materials and installation. The HDPE pipe shall comply with ASTM D-3350 or ASTM F-714. Unless otherwise indicated, liner for pipe shall conform to SDR 32.5, minimum.

500-1.7.2 Material Composition. Pipe shall be made from HDPE resins complying with ASTM D-1248. Type III, Class C, Category 5, Grade P 34, and ASTM D-3350, and shall also meet the requirements of Subsection 207-19.2, except that titanium dioxide pigment may be substituted for the 2 percent carbon black.

The Contractor shall provide certified test results for approval by the Engineer, from the manufacturer, that the material conforms with the applicable requirements, including crystallization temperatures.

500-1.7.3 Material and Equipment Acceptance. Material and equipment acceptance shall conform to Subsection 207-19.3.

500-1.7.4 Marking. Marking shall conform to Subsection 207-19.4.

500-1.7.5 Chemical Resistance and Physical Testing. HDPE pipe specimens shall comply with Subsection 207-19.5 except the requirements shall be met with samples from pipe that has experienced the deformation and reforming process.

500-1.7.6 Installation and Field Inspection. HDPE pipe shall be installed as follows:

A. The existing pipeline shall be cleaned of any obstruction, televised, and the condition approved by the Engineer prior to the insertion of the deformed pipe.

B. A cable shall be strung through the existing pipe to be rehabilitated and attached to the deformed pipe through an existing manhole or access point. The pipe is then pulled through the existing conduit by this cable. Care shall be taken not to damage the deformed pipe during installation.

Appropriate sleeves and rollers shall be used to protect the pipe.

C. When the deformed pipe is in place, the pipe shall be cut and the processing manifolds (pipe end closing assembly used for heat and pressure control within liner) shall be inserted and secured at both pipe ends. The temperature and pressure measuring instruments shall be attached to the deformed pipe at both ends.

D. Through the use of steam and air pressure, the deformed pipe shall be progressively reformed to conform to the existing pipe wall. The deformed pipe shall be pressurized up to 14.5 psig, maximum, while the termination point valves are kept open to provide heat flow. The pressure shall be increased in increments up to a maximum of 26 psig.

E. The Contractor shall cool the reformed pipe to the approved manufacturer recommendations. When the temperature reduces to 100^{o}F, the Contractor will then slowly raise the pressure to approximately 33 psig, while applying air or water for continued cooling. The equipment shall be disconnected after ambient temperature is attained.

F. Temperatures and pressures shall be monitored and recorded throughout the installation process to ensure that each phase of the process is achieved at the manufacturer's recommended approved temperature and pressure levels.

500-1.7.7 End Seals. The beginning and end of the new HDPE pipe shall be sealed to the rehabilitated pipeline. If sealing material is required, it shall be compatible with the HDPE pipe and shall provide a water tight seal.

500-1.7.8 Service Connections. Existing service connections shall be reinstated through the use of a remote control unit or excavation.

NTS - reference to pertinent Section paragraphs:

500-1.7.1 Existing pipes having large holes and/or pieces missing may prove to seriously inhibit the use of this alternate.

500-1.7.3 It is imperative that the equipment is functioning properly in that the entire operation is sensitive to temperature and pressure control.

500-1.7.6 The deformed pipe shall be covered with protective wrap or be contained within a mobile installation unit. Safety measures shall be implemented at the site, including information dispatch to citizens about the area work. The installation unit shall contain a properly operating instrumentation control console, steam and pressure generating equipment and other auxiliary equipment for process control.

500-1.8 Reinforced Plastic Mortar Liner Pipe

500-1.8.1 General - Fiberglass Reinforced Plastic Mortar (RPM) Liner pipe for use in lining sanitary sewers shall comply with ASTM D-3262. Unless otherwise indicated, the minimum pipe stiffness shall be 18 psi as measured by testing in accordance with ASTM D-2412.

Pipe Stiffness (psi)	**Maximum Hydrostatic Head (ft.)* for Ungrouted Installation**
18	10
36	21
46	27
72	43
(any pipe stiffness)	(0.6 P.S.)

* Groundwater surface to bottom of liner pipe

Note: Safety factor and grout support factor not included.

500-1.8.2 Material Composition - Pipes, joints and fittings shall be made from thermosetting resin, glass fiber reinforcements and silica sand in combinations meeting all requirements of this Section. Designation per ASTM D-3262 shall be type 1 or 3, liner 2, grade 3 or 5 and pipe stiffness B, C, D, or as indicated in the Special Provisions. Rubber gaskets shall conform to the requirements of ASTM F-477.

500-1.8.3 Liner Pipe Acceptance - At the time of delivery the liner pipe shall be free of cracks, holes, delaminations, foreign inclusions, blisters or other defects that would, due to their nature, degree or extent, have a deleterious effect on the pipe performance. Repairs to the liner pipe, if needed, shall be approved by the Engineer.

For testing purposes, a production lot shall consist of all liner pipe having the same lot marking number but shall not exceed a total of 100 pipes per ASTM D-3262. Pipe length, wall thickness, joint dimensions, pipe stiffness and deflection characteristics shall be verified for each lot per ASTM D-3262 requirements.

500-1.8.4 Marking - Each pipe section shall be marked both inside and outside, at both ends and every five (5) feet on the outside, as follows:

* Manufacturer
* Manufacturing Number
  (Identifies factory location, date, shift and sequence)
* Nominal Diameter
* Nominal Pipe Stiffness

* ASTM D-3262 and Designation
* Lot Number

500-1.8.5 Chemical Resistance and Physical Testing - Liner pipes and gaskets shall conform to the requirements of Subsection 210-2.3.3.

500-1.8.6 Installation and Field Inspection - The existing sewer shall be maintained in operation during the relining process. Obstructions such as roots, large joint off-sets, rocks or other debris, etc. that would prevent passage or damage to the liner pipe sections shall be removed or repaired prior to installing the liner pipe(s). Liner pipes shall be inserted one section at a time through an access pit constructed above the existing sewer. The top of the existing sewer exposed in the pit should be removed down to springline level (halfway). Liner pipes shall be inserted spigot end first with the bell end trailing. The pushing force shall be applied to the pipe wall end inside of the bell. Maximum jacking load shall not exceed the following:

Nom. Dia. (in)	**Safe compressive load (Tons)**	
	P.S. 18	**P.S. 36**
18	--	17
20	--	19
24	23	31
30	36	52
36	52	66
42	71	95
48	93	130
54	123	171
60	155	212
66	175	240
72	209	292
78	252	351
84	307	422

90	357	485
96	411	560

Note: Factor of Safety of 4 is included for longitudinal compressive load.

500-1.8.7 Grouting Annulus - The entire annular space between the outside of the liner and the inside of the existing pipe shall be grouted. The grout mix and placement procedure shall be submitted to the engineer for approval, in accordance to Subsection 2-5.3. Grouting of the annular space shall be done in such a manner as to prevent damage or collapse of the liner. Maximum safe grouting pressure (psi) is equal to the pipe stiffness divided by 3.

When grouting is not required, refer to the maximum hydrostatic head for the ungrouted installation (Section 500-1.8.1) to determine the appropriate pipe stiffness. The liner shall be sealed in both directions at the manholes to a depth of 12 inches minimum.

500-1.8.8 Service Connections - Service laterals shall be connected to the liner pipe by use of a mechanical saddle approved by the engineer.

NTS - referenced to pertinent Section paragraphs:

500-1.8.6 Jacking or pipe push pits are constructed approximately 25 feet long by OD plus 2 feet wide to accommodate the 20 foot long pipe joints. In the event the existing pipeline alignment is curvilinear, short pipe joints must be utilized. It is necessary to determine the geometry in advance of the work. Also, the Contractor should proof the existing pipeline in advance of the sliplining work.

500-1.8.7 Annulus grouting technology is still in its developing stages. The 1993 Greenbook Supplement should have the latest state of the art.

500-1.8.8 Service connections rarely used on large diameter pipe are occasionally needed. It is currently recommended that the Inserta-Tee connections are the most proven.

500-1.9 External Inplace Wrap (PVC)

500-1.9.1 General. Where accessible, existing sewer pipes experiencing crown corrosion may be rehabilitated utilizing a wrap of PVC liner with integral mechanical locking extensions followed by a cap of reinforcing steel and concrete. The installation of all plastic liner shall be done in accordance with Plans and Specifications.

Plastic Liner Sheet, weld strip, adhesive products, and cleaners shall be in accordance with Section 210-2. Prior to plastic liner installation, the existing line shall be uncovered and pipe exposed below the low flow line as specified. Liner shall be applied and secured to the existing pipe, inspected and approved by the engineer prior to placement of reinforcing steel and concrete.

500-1.9.2 Installer Qualifications. Applicators and welders shall be qualified in accordance with 311-1.2.

500-1.9.3 Preparation of existing pipe for installation of plastic liner. The concrete surface shall be etched by sandblasting to develop a slightly granular surface. When permitted by the Engineer, the concrete surface may be acid etched in lieu of sandblasting.

After sandblasting, the concrete surface shall be thoroughly cleaned of dust. Surfaces etched with acid shall be thoroughly washed with clean water and completely dried before applying primer.

500-1.9.3.1 Coverage. The circumferential coverage shall be

the upper 270° unless otherwise shown on the Plans or indicated in the Special Provisions.

After the liner is installed, the offset of each longitudinal terminal edge of sheet shall not be greater than 12 inches.

500-1.9.3.2 Positioning Liner. Liner installed on the existing pipe shall be positioned with the locking extensions outward and aligned with or perpendicular to the longitudinal axis of the pipe.

Liner shall be centered with respect to the field top centerline of the pipe. Liner shall be set to fit over the existing pipe joints with the field welded seams located on the flat barrel portion of the pipes. Liner shall be closely fitted to the existing pipe. Sheets shall be cut to fit curved and warped surfaces using the minimum number of separate pieces.

Prior to installation, the contractor shall indicate to the Engineer the proposed layout of liner sheets, including the location and type of all field welds.

The Engineer may require shop drawings, per Subsection 2-5.3, or the use of patterns or the marking of sheet layouts directly on the existing pipe where complicated or warped surfaces are involved.

At transverse joints between sheets of liner used along the pipeline, the space between ends or edges of locking extensions, measured longitudinally shall not exceed 4 inches.

500-1.9.3.3 Securing Liner in Place. Liner shall be held snugly in place against the existing pipe by use of adhesive materials, in accordance with liner manufacturer's written recommendations as approved by the Engineer.

Liner shall be bonded to the existing pipe a minimum of six (6) inches along both longitudinal bottom terminal

edges. This shall be accomplished by the application of an approved Adhesive System.

500-1.9.4 Field joining of Liner

500-1.9.4.1 General. Liner at joints shall be free of all mortar and other foreign material and shall be clean and dry before joints are made. All field joints are to be made and tested prior to placement of reinforcing steel and concrete.

500-1.9.4.2 Field Joints in Pipe Rehabilitation Installation. Field joints in the liner plate shall be one of the following types:

1) Type R-1 joint shall consist of a 2-inch wide weld strip, centered over the 1-inch maximum gap between sheets and securely welded along each edge of adjacent liner.

2) Type R-2 joint shall be made with an integral joint flap with locking extensions removed per Subsection 210-2.4.6, extending 12 inches "3 inch beyond the end of the sheet. The sheet shall be overlapped not less than 2 inch and the overlap secured to the adjacent liner by means of a 1-inch welding strip. The downstream sheet shall overlap the upstream sheet.

3) Type R-3 joint shall consists of a 1-inch wide weld strip centered over a 3 inch maximum gap between sheets and secured along each edge of adjacent liner by means of a 1-inch welding strip.

Note: The Type R-2 is the recommended joint for normal liner installation. Type R-1 and R-3 joints are acceptable, but should be used only when actual installation requires this flexibility.

500-1.9.4.3 Installation of welding strips shall be in accordance with 311-1.5.4.

500-1.9.5 Protection and repair of liner shall be in accordance with 311-1.9.

500-1.9.6 Field testing shall be in accordance with 311-1.10 and 210-2.3.6.

500-1.9.7 Steel Reinforcement

500-1.9.7.1 General. Before placing reinforcement steel, the Contractor shall submit a reinforcing steel placing plan in accordance with the provisions of Shop Drawings, per Subsection 2-5.3.

Reinforcing bars shall be placed in accordance with the size and spacing shown on the Plans. They shall be held in position by the use of concrete or plastic chairs when chaired against the plastic liner. Metal chairs shall not be allowed for chairing against the plastic liner.

Caution shall be taken when installing reinforcing steel to ensure against puncturing or damaging the liner. If damage occurs to the liner, the liner shall be repaired and retested.

500-1.9.8 Concreting Operations

500-1.9.8.1 Concrete Placement. Concrete placed against liner shall be carefully conveyed, deposited and consolidated so as to avoid damage to the liner and to produce dense concrete securely anchoring the locking extensions into the concrete. Internal vibrators shall be used to consolidate concrete with particular attention along the lower terminal edge of the liner.

500-1.9.8.2 Forms. Often the trench walls themselves serve as the outer form for the new concrete encasement. When outer forms are required, they shall be of suitable material and a type, size, shape, quality and strength to ensure construction as designed.

NTS - referenced to pertinent Section paragraphs:

500-1.9.1 The External Inplace PVC Wrap will probably not be used often, however, occasionally a Point Repair or short distance repair should prove to be viable. When pipelines experience surcharging, this method should normally not be considered.

500-1.9.3 The excavation of the existing pipeline and careful cleaning around the pipeline is mandatory in advance of the wrapping.

500-1.10 Folded PVC Sewer Rehabilitation System

500-1.10.1 General. Folded Polyvinyl Chloride extrusion material shall be introduced into sanitary sewers and storm drains in order to rehabilitate the existing pipeline system without excavation. This method applies to the rehabilitation of 4" thru 12" diameter pipe in terms of materials and installation. The dimension ratio shall be DR 35 in relation to the nominal pipe diameter.

500-1.10.2 Material Composition. The folded pipe shall be made from PVC resins having a cell classification of 12334-B or 12454-B, as defined in ASTM D-1784. The pipe shall also be in conformance to Subsection 207-17.2.2, except for the dimensional requirements.

500-1.10.3 Material and Equipment Acceptance. At the time of manufacture, the extruded material shall be

inspected for defects and physical properties in accordance to the ASTM D-1784, or as indicated in the Special Provisions.

At the time of delivery, the material shall be homogeneous, free of defects, cracks, holes, blisters, foreign materials or other deleterious faults. The material shall also conform to the requirements listed in Subsection 207-17.4.2.

The Contractor shall furnish and maintain, in good condition, all equipment necessary for proper execution and inspection of the work.

500-1.10.4 Marking. Marking shall conform to the requirements of Subsection 207-17.2.1.

500-1.10.5 Chemical Resistance and Physical Testing. The PVC material shall be tested in accordance with Subsections 207-17.5 and 210-2.3.3. The various requirements shall be met with samples taken from pipe that has experienced the folding and rerounding process.

500-1.10.6 Installation & Field Inspection:

A. The existing pipeline shall be cleaned of any obstacles, televised, and the condition shall be approved by the Engineer prior to the insertion of the folded pipe.

B. A heat containment tube shall be placed inside the host pipe for the retention of heat necessary to soften the folded pipe.

C. A cable shall be strung through the existing pipe to be rehabilitated and attached to the folded pipe through an existing manhole or

access point. The heated flexible pipe is then pulled through the existing conduit by this cable. Care shall be taken not to damage the folded pipe during installation.

D. After it is fully extended within the existing pipe, the folded pipe shall be cut off at the starting point.

E. Through the use of steam and air pressure the folded pipe is progressively unfolded and rounded to conform to the existing pipe wall providing a tight-fitting pipe within a pipe.

F. The Contractor shall cool the rounded pipe to a temperature as approved per manufacturer recommendation before relieving the pressure required to hold the rounded pipe against the existing pipe wall.

G. Temperatures and pressures shall be monitored throughout the installation process to ensure that each phase of the process is achieved at the desired temperature and pressure levels.

H. Repairs to the finished folded pipe, if needed, shall be approved by the Engineer.

500-1.10.7 End Seals. When required by the Engineer, the beginning and end of the new PVC pipe shall be sealed to the host pipeline structure in order to prevent water movement between the two systems. The material shall be compatible with the PVC pipe and shall provide a water tight seal. Sealant systems and materials shall conform to the requirements of Subsection 210-2.3.3.

500-1.10.8 Service Connections. Existing service connections shall be reinstated through the use of a remote control unit or excavation.

NTS - referenced to pertinent Section paragraphs:

500-1.10.1 Existing pipes that have pieces missing may prove to seriously inhibit the use of this alternate. The heat containment tube should provide some support for the PVC pipe liner.

500-1.10.3 It is imperative that the equipment is functioning properly in that the entire operation is sensitive to temperature.

500-1.10.6 The deformed pipe shall be covered with protective wrap or be contained within a mobile installation unit. Safety measures shall be implemented at the site, including information dispatch to citizens about the area work. The installation unit shall contain a properly operating instrumentation control console, steam and pressure generating equipment and other auxiliary equipment for process control.

SECTION 500-2 - MANHOLE AND STRUCTURE REHABILITATION

500-2.1 Requirements

500-2.1.1 General. This section covers the various manhole and structure rehabilitation materials and methods. The type(s) of rehabilitation materials and methods for a given project shall be designated on the Plans. The Engineer shall require testing of the materials and methods for compliance with these requirements prior to delivery to the job site and/or prior to acceptance depending upon the alternate selected.

500-2.1.2 Manhole Steps. Manhole steps shall be installed or removed as indicated on the Plans or Special Provisions.

500-2.1.3 Safety. Contractor shall comply with all Federal, State, Local and CAL OSHA safety regulations. Contractor's personnel shall be certified for confined space entry.

500-2.1.4 Removal and Disposal. Contractor shall be responsible for removal and disposal of all debris removed during the cleaning and rehabilitation process. Contractor shall comply with all Federal, State and Local regulations regarding disposal of debris.

500-2.1.5 Measurement and Payment. Manhole and structure rehabilitation shall be measured along the longitudinal axis between the ends of the manhole or structure as shown on the plans to the nearest 0.1 foot.

Payment for structures, including but not limited to manholes, junction structures and lampholes shall be made at the contract unit bid price for each structure and shall be full payment for point repair and rehabilitation for each structure complete in place including all labor, material, tools, equipment, apparatus and incidentals necessary for excavation, backfilling, reconstructing inverts, furnishing and installing castings, restoration of the street or ground surface, and all other required work.

500-2.2 Manhole Performing System

500-2.2.1 General. This Subsection describes the installation of the Integral Locking PVC Liner by temporarily erecting a form inside an existing manhole and filling the annular space between the erected form and the existing manhole wall with concrete or other approved materials that will result in a new PVC lined monolithic manhole within the old one. This work is for sanitary sewer manholes. The same preforming system can be utilized for storm drain manholes, except when indicated on the plans or special provisions, the PVC liner may not be required.

500-2.2.2 Concrete. Concrete, unless otherwise specified by the Engineer, shall be Class 560-C-3250 per Subsection 201-1.1.2.

500-2.2.3 Integral Locking PVC Liner. The liner shall comply with the applicable requirements in Sections 210-2 and 311.1, unless shown otherwise on the drawings or specifications.

500-2.2.4 Chemical Resistance and Physical Testing. The Intregal Locking PVC Liner shall meet the requirements of Subsection 210-2.3.3.

500-2.2.5 Installation and Field Inspection. The manhole walls and base shall be free of loose debris by brushing or low pressure washing. Steps or obstructions that prohibit proper erection of the interior formwork shall be removed to a depth of 1 inch minimum inside the structure. The formwork shall be installed in a manner that substantially fits the existing walls of the manhole and creates an equal and approximate three (3) inch annular space. Concrete or other materials, as indicated on the plans or special provision, shall be used to fill the annular space. The installation of the Integral Locking PVC Liner shall comply with Section 311-1.

500-2.2.6 Service Connections. Existing lines to the manholes shall be extended through the newly formed manhole wall. The exposed concrete surfaces within the manhole shall be protected as indicated on the plans or special provisions.

NTS - reference to pertinent Section paragraphs:

500-2.2.2 Concrete. Normal slump test should be run on each concrete pour for assuring proper quality.

500-2.2.5 Installation and Field Inspection. It is important to remove all deteriorated concrete, down to concrete that is intact, and structurally sound, in order to facilitate a good bond for the new concrete pour. Care should be taken at the base of the steel forms for proper seating and protection of all inlet/outlet piping.

500-2.2.6 Service Connections. The service laterals entering the manhole should be complete, providing total protection to the bare concrete.

500-2.3 PVC Manhole and Wet Well Lining Systems

500-2.3.1 General. This Subsection describes the installation of the PVC Liner by placing the liner strips so that an annular space is created between the PVC Liner and the existing manhole/wet well. This annular space is then filled with cementitious grout or other approved materials that will result in a monolithic manhole/wet well within the existing manhole/wet well.

500-2.3.2 Materials

500-2.3.2.1 PVC Liner. The PVC Liner shall comply with the applicable requirements in Sections 500-1.5 (PVC Sewer Lining System).

500-2.3.2.2 Grout. Cementitious grout or other approved materials shall conform to Subsection 500-1.1 and as indicated on the plans or special provisions.

500-2.3.2.3 Sealant/Adhesive. Sealant/adhesive shall be as indicated on the plans or special provisions.

500-2.3.3 Chemical Resistance. The PVC material and sealant/adhesive furnished under this Subsection shall

conform to Subsection 210-2.3.3.

500-2.3.4 Installation and Field Inspection. Surface preparation shall consist of through cleaning to remove all loose material and surface contaminants.

Any protrusions on the wall surface which interfere with the installation of the liner shall be removed. The Contractor, when required, shall provide for the flow of sewage around the manhole/wet well designated for lining. Installation shall be accomplished by either manually spirally winding the PVC Strip or manually placing the PVC Panels and by engaging the complimentary locks (male/female) at the edges of the strips/panels in a manner which creates the annular space, as specified and approved by the Engineer.

A bead of sealant/adhesive, approved by the Engineer, shall be applied to the female locking edge of the strip/panel prior to engaging the locking edges. Cementitious grout or other approved materials, as specified by the Engineer and as indicated on the plans or special provisions, shall be used to fill the annular space. The grout mix and placement procedure shall be submitted to the Engineer for approval in accordance with Subsection 2-5.3. Grouting of the annular space shall be done in such a manner as to prevent damage or collapse of the liner. Any holes in the plastic shall be covered with a patch of similar material as approved by the Engineer. The installation of the PVC Liner shall comply with the applicable requirements of Subsection 500-1.5.

500-2.3.5 Service Connections. Service connections shall be reestablished with the liner in accordance with manufacturers written recommendations as approved by the Engineer.

NTS - referenced to pertinent Section paragraphs:

500-2.3.2.2 Concrete. Normal slump test should be run on each concrete pour for assuring proper quality.

500-2.3.4 It is important to remove all deteriorated concrete, down to concrete that is intact, and structurally sound, in order to facilitate a good bond for the new grout pour. Care should be taken at the base of the PVC liner for proper seating and protection of all inlet/outlet piping.

500-2.3.5 Service Connections. The service laterals entering the manhole should be complete, providing total protection to the bare concrete.