GRAVITY SEWER PIPE REHABILITAION

GENERAL REQUIREMENTS FOR THE INSTALLATION OF LINING SYSTEMS

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DOCUMENT CONTROL

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Definitions

ASTM	American Society for Testing and Materials
ASTT	Australasian Society for Trenchless Technology
CCTV	Closed Circuit Television – which includes cameras and displays to record and inspect pipelines.
CIPP	Cured in place pipe
Contractor	Main Contractor engaged by Watercare, responsible for delivering the works
Curing	The process of resin polymerisation, which may be initiated or accelerated using heat or ultraviolet light.
Defect	Any discontinuity, imperfection or inclusion arising from substandard materials, improper pipe preparation, or faulty manufacture, installation or workmanship which affects the hydraulic or structural performance of the lining
DN	Nominal Diameter
Flow management plan (FMP)	Contractor plan(s) and methods to divert flows whilst preventing overflows or any adverse consequences whilst preparing the host pipe and installing the new liner.
Full length liner	Lining a complete section of sewer between two access points / manholes.
Grouting	Filling of voids between the lining system and existing pipe, generally using a cementitious based product, with a specified strength
In-line rehabilitation	Pipeline rehabilitation method which can be installed whilst the pipeline is still in operation (or at a reduced flow rate)
ISO	International Organisation for Standardisation
JSA	Job safety analysis
Laser profiling	Laser which projects onto the pipe's surface to measure and analyse features including diameter and ovality which can be used to derive capacity.

Lateral Junction repair (LJR)	Repair made with CIPP technology to a damaged lateral connection, either stand alone or in conjunction with a full or part liner
Lining system	Lining pipe or material for insertion into an existing pipeline for renovation
NZTA	New Zealand Transport Agency
NDSRs	No-dig spot repairs – repairing a localised section of pipe between manholes.
NZGPIM	New Zealand gravity pipe inspection manual
Performance Specification	General minimum requirements set out by the Principal (Watercare)
Pipe	In the context of this document, a pipe may include network and transmission pipelines, tunnels, and culverts which are either round or ovoid in shape.
Project Specification	Project specific requirements specified by the design engineer or Contractor which form part of the minimum requirements to be met during construction.
Quality Control Plan	The Contractor's documentation that defines the procedures for delivering the level of construction quality required by the project.
Specialist Contractor	Contractor carrying out the physical installation of the liner in accordance with the project specifications and manufacturer's recommendations.
Watercare	Watercare's representative responsible for managing the project.

Table of Contents

1. Scope

This Performance Specification covers general requirements for the installation of lining systems in gravity sewer pipes to restore their design structural integrity, watertightness, hydraulic capacity and to prevent root ingress, corrosion and erosion of internal pipe walls or surrounding bedding, or any combination of these. Lining systems may cover the full length between access chambers; or an isolated defects (patch repairs) wherever applicable.

Applications of gravity sewers include:

- Network wastewater pipes.
- Reinstatement of public laterals and lateral junction repairs (LJRs).
- Overflow pipes.
- Bulk sewer interceptor (transmission) pipes.
- Culverts and tunnels.

This specification also covers the general requirements for rehabilitation of defective gravity sewer pipelines using one or more of the rehabilitation methods presented in Section 1.2, including; preparation and cleaning, management plan requirements, and general quality control requirements.

The requirements and provisions of this document shall apply to all gravity sewer pipe rehabilitation methods presented in Section 1.2, unless otherwise specified in the relevant specific lining method Performance Specification Guidelines *ESF-600-STD-207 to ESF-600-STD-211*.

1.1 Interpretation

Unless specifically stated, rehabilitation of gravity sewer pipes shall follow ALL requirements described in this Performance Specification and the provision of any supplementary materials and/or services which are not described but are reasonably necessary to achieve a fully functional sewer system with the expected level of integrity.

It is not intended that this Performance Specification prevent the use of gravity sewers rehabilitation methods other than those listed in in Section 1.2, such as hydraulic cement and polymer-based lining, polymer injection and pipe surface chemical treatment. Watercare encourages best practice innovation to meet the performance and integrity outcomes of each project. However, Watercare considers that in typical situations, the methods outlined in these specifications are generally those most acceptable to all concerned. Any alternative method of rehabilitation shall be subject to Watercare approval on case-by-case bases.

1.2 Gravity sewer rehabilitation methods

The range of acceptable pipe rehabilitation methods for gravity sewers are outlined below.

- **Cured in Place Pipe -** Circular and non-circular (ovoid) host pipes lined with a flexible, resin impregnated tube, pushed by inversion or drawn into place, and inflated. Curing of resin is accelerated using heat or ultraviolet light.

- **Spiral Wound Lining -** Circular host pipes lined by winding and expanding, or winding to the pipe diameter, a continuous plastic interlocking strip to form a new internal pipe. The

ends at each chamber / manhole are sealed, and the annular gap can be grouted to strengthen the liner.

- **Slip Lining -** Circular host pipes lined with reduced diameter pipes that are joined into a continuous length and drawn through each section.

- **Fold and Form Lining -** Circular host pipes lined through expansion of a continuous coil of a specifically formulated PVC or PE pipe which is drawn through each section.

- **Segment Lining -** Circular and non-circular (ovoid) host pipes lined by jacking pipe or moulded segments with vertical or horizontal joints through the host pipe. This method generally requires that the segment be bonded to the existing pipe using an appropriate grouting technique.

2. Relevant Standards

Table 1 below lists the general standards applicable to the rehabilitation of gravity sewer pipes. A comprehensive list of standards relating to specific methods are covered in the respective Performance Specification Guidelines listed below:

- ESF-600-STD-207: Cured in Place Pipe (CIPP) Lining - Performance Specification Guideline.
- ESF-600-STD-208: Spiral Wound Lining - Performance Specification Guideline.
- ESF-600-STD-209: Slip lining - Performance Specification Guideline.
- ESF-600-STD-210: Fold and Form Lining - Performance Specification Guideline.
- ESF-600-STD-211: Pipe Segment Lining - Performance Specification Guideline.

***Table 1**: General standards applicable rehabilitation of pipelines*

Standard	Relevance
AS/NZS ISO 11295: Plastics piping systems used for the rehabilitation of pipelines - Classification and overview of strategic, tactical and operational activities	Planning and general
AS/NZS ISO 11296.1: Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks, Part 1: General	Planning and general
ASTT – DS-D001 Specification: Design for Structural Renovation of Pipelines by Internal Lining, Part 1 – Circular Non-pressure Pipelines	Design [(a)]
NZTA Bridge Manual – SP/M/022	Design
AS/NZS 2566.1:1998: Buried flexible pipelines – Part 1: Structural design	Design
ASTM F1216: Standard practice for rehabilitation of existing pipelines and conduits by inversion and curing of a resin-impregnated tube	Design and installation - CIPP
ASTM F2561: Standard practice for rehabilitation of a sewer service lateral and its connection to the main using a one piece main and lateral cured-in-place liner	Construction
CG: General Civil Construction Standard	Construction

(a) Not applicable to segment liners

Note: The latest revisions of the standards listed above shall be referred to when carrying out any of the associated works

3. Design

The design life of the newly rehabilitated system (liner and host pipe) shall be at least fifty (50) years.

The lining shall be designed in accordance with either ASTT – DS-D001 or the appropriate ASTM standard for one of the following loading cases:

- **Fully deteriorated pipe**: when the host pipe is considered to have no remaining strength and is no longer capable of supporting loads or is expected to reach this condition over the design life of the rehabilitation system.
- **Partially deteriorated pipe**: when the host pipe is assessed as capable of supporting applied loads from soil, other dead loads and traffic loads. The liner therefore shall be designed to withstand hydrostatic load from ground water. This case might be considered, for example, when pipes are rehabilitated to stop leaks from joints, ingress of roots or corrosion of pipe walls while the original pipe reinforcement are still intact.

A fully deteriorated pipe shall be assumed unless demonstrated to Watercare's satisfaction that the host pipe is still structurally intact. Acceptance of an intact pipe by Watercare will then permit design for partially deteriorated condition.

Full details of the design calculations shall be provided and shall be specific to the size, loadings, and other conditions relating to each section of lining.

Calculation documentation shall state all the assumptions made, indicate the values of all parameters used in the designs, and any relevant formulae or other information utilised to determine the lining profile required. The design shall take the following into account:

- Dead load (e.g. soil loads).
- Live Load (e.g. traffic loads).
- Groundwater table and hydrostatic pressure effects.
- Chemical characteristics of the soil and groundwater.
- Hydraulic capacity requirements.
- Wastewater characteristics.
- Resistance to corrosive substances.
- Host pipe condition, ovality, material & thickness, and joint seal integrity.
- Rehabilitation material physical properties.

The lining shall be designed and fabricated in a manner that, when installed, will fit the internal wall and length of each section of the pipe being lined, within the tolerances nominated by the manufacturer or designer. Where lining technology requires, suitable allowance shall be provided for longitudinal and circumferential stretching or shrinkage of the lining during installation.

Notes:

- Review of design calculations shall not be construed as acceptance of the calculations. Responsibility for the design shall remain with the Designer.

- ASTT and ASTM design standards are specified due to their simplicity, track record and conservative approach. However, Watercare will consider an alternative FEA design for major and or critical projects, where such design might yield a more feasible and better performance outcome.

3.1 Design loading

3.1.1 Fully Deteriorated Pipe Case:

For fully deteriorated pipe lining, the design shall assume that in the long term there will be no remaining bond between the host pipe and the lining.

The finished liner shall be designed to be capable of carrying the following loads wherever applicable:

The vertical load due to weight of the soil prism on top of the pipe calculated in accordance with ASTT DS-001 with no allowance for Silo Reduction Factors, unless otherwise approved by Watercare. The depth of ground cover above the pipeline can be determined from available plans, long sections and survey information.

3.1.1.1 Superimposed live loads

The following superimposed loads shall be considered during the design:

- External hydrostatic load; from ground water pressure assuming the water table at ground level unless water table data indicate otherwise.

Superimposed live loads calculated as follows:

- For pipes under vehicle lanes of Motorways and Expressways; the superimposed live load on the liners shall be calculated as the average intensity due to HN-HO-72 loading on top of the liner distributed, as per NZTA-Bridge Manual SP/M/22.

- For pipes under vehicle lanes of Artery Roads; the superimposed live load on the liners shall be calculated as the average intensity due to HN-HO-72 loading on top of the liner distributed, as per AS/NZS 2566:1:1998.

- For pipes under vehicle lanes of Secondary Roads; the superimposed live load on the liners shall be calculated as the average load intensity due to HN loading on top of the liner, distributed as per AS/NZS 2566:1:1998.

- For pipes under other areas such as, railways, parks, residential and commercial buildings/ structures; the superimposed live load on the lines shall be determined by the liner designer and submitted to Watercare for approval.

The design loading utilised for any single length of pipe shall be the maximum load produced from the combination of all above loadings over that length.

3.1.2 Partially deteriorated pipe case

The liner shall be designed to withstand groundwater pressure, such as may be applied through joints or cracks in the surrounding pipe wall. Ground water level shall be assumed to be at ground level, unless water table data is available to show otherwise.

The lining shall be designed and fabricated in a manner that, when installed, will fit the internal wall and length of the pipe being lined, within the tolerances specified by the designer.

All work on the preparation of the design calculations, including proof checking and review, shall be included in the Contractor's quality assurance documentation.

The liner, grout (where required), and any other lining materials supplied shall conform to the parameters set out in the liner design.

Note: The design should specify appropriate parameters for the expected conditions such that the liner is adequate for the expected general and worst-case conditions. Overconservative and uninformed assumptions may lead to excessive cost and risk. It is therefore encouraged that these parameters and assumptions be justified, or more accurate information be obtained to achieve an appropriate and acceptable design.

3.2 Hydraulic requirements

The lining system must achieve the required hydraulic capacity to service the network performance requirements.

Any reduction in the pipe cross-sectional area shall be compensated by the reduced roughness of the liner to achieve the required hydraulic capacity.

The build-up of slime, film and any defects, which may affect hydraulic performance over time, shall be considered when designing the liner.

3.3 Degree of fit

The lining system shall be designed to neatly fit the inside and along the carrier pipe.

4. Material requirements

4.1 General

Wherever relevant, only materials and manufacturers listed and / or accepted by Watercare shall be used.

The Contractor shall comply with all recommendations of the manufacturers regarding the storage and handling of materials. All handling, transport and storage shall be carried out such that no damage occurs to the materials including coating, lining and labelling.

The Contractor shall submit test data to substantiate that the material properties nominated in the design calculations can be achieved by the materials supplied for the lining installation. These include, but are not limited to strength, elasticity and water tightness.

Where appropriate, the manufacturer shall provide a product statement as part of the design. This shall detail the material composition, wall structure and thickness of the pipe product. The installed lining shall meet the submitted product statement.

The material properties of the lining material used in the rehabilitation of the pipe shall be consistent with the design parameters, as nominated by the designer.

4.2 Product submittals

The Contractor shall submit the following product information:

- Manufacturer's product description and curing process (if applicable).
- Manufacturer's recommended patch repair methods for host pipe (if applicable) and any installation defects.
- The manufacturer's shipping, storage and handling instructions (including shelf life, if relevant).
- The manufacturer's recommended installation procedure (if applicable).

4.3 Chemical, temperature and abrasion resistance

The lining system shall consist of materials that are chemically and biologically resistant to internal exposure of sewage, sewage related gases and mild concentrations of industrial (trade waste) effluent, for the duration service life of the lining system.

Chemical resistance shall include satisfactory performance in the presence of small quantities of carbon monoxide, carbon dioxide, methane, hydrogen sulphide, sewer gas saturated with moisture, traces of mercaptans, gasoline, vegetable oil, kerosene, tap water (pH 5.5 - 9), detergent, soap, and dilute concentrations of sulphuric, nitric and phosphoric acid, and any other product generally within the requirements documented in the current version of Watercare's Trade Waste Bylaws.

The Trade Waste Bylaws permit wastewater temperatures up to 40 degrees Celsius. Unless specified elsewhere, the liner shall be suitable for operation at this temperature.

The lining system shall also be resistant to external exposure of soil bacteria and any chemical attack that may be due to residues remaining on the pipe wall, products from degradation of the existing host pipe, groundwater (including salinity in coastal regions), or elements in the surrounding ground.

Flow conditions in sewers generally pose a risk of accelerated wear due to accumulation of grit and debris, hydro-jet cleaning at high pressures and the use of mechanical cleaning devices.

The lining shall have sufficient abrasion resistance to accommodate the migration of silt, sand, and debris along the pipe. It shall also be sufficiently robust to withstand damage by pipe cleaning equipment that may be required to remove future blockages or debris in the pipe.

The installed liner and its component materials shall not be subject to shrinkage, thermal contraction, recovery, or reversion that adversely affects its strength, water tightness, fixings and sealing at the ends and openings, or hydraulic performance.

The lining material and configuration shall have satisfactory structural properties to meet the design criteria.

5. Construction

The general sequence of events during the construction phase include:

- Complete Watercare's Health and Safety induction.
- Submission and acceptance of Watercare's ***Control of Work*** documentation.
- Submission and acceptance of a Work Method Statement (construction management plan).
- Submission and acceptance of a sewer Flow Management Plan.
- Submission and acceptance of Quality Control Plan.
- Approvals from stakeholders, property owners and controlling authorities (i.e. road, rail corridors) as relevant.
- Cleaning and preparation of the pipeline.
- Confirmation of pipe sizes and location of lateral connections.
- Preparation after cleaning.
- CCTV inspection prior to liner installation. (Note cleaning and CCTV may require more than one iteration to ensure conditions are satisfactory before the installation of the liner commences)
- Liner installation, including reinstatement of lateral connections.
- Grouting lining annulus (if applicable).
- End termination and sealing around liner at manholes.
- Complete post installation CCTV inspection.
- Leak testing (as required).
- Cut out laterals.
- Install LJR's (as required).
- Final CCTV.
- Measurement of final internal dimensions
- Testing and sampling of liner (as required).
- Remediate all defects.
- Reinstatement of site.
- Submission and acceptance of handover documentation.

5.1 Pre-construction

5.1.1 General

The installation Contractor shall confirm the suitability of each pipe section for lining, and assess and confirm the preparation works required, prior to undertaking any physical lining works.

For each liner installation, the *Specialist Lining Contractor* shall provide a confirmation statement that the proposed liner will conform to the details provided in the *Project Specification* and confirm that lining will comply with design parameters.

5.1.2 Safety

All work shall be conducted in accordance with the requirements of the Health and Safety at Work Act 2015. All Contractors shall undergo a Health and Safety induction programme provided by Watercare prior to any work progressing. Part of this process involves completing the steps outlined in Watercare's Control of Work System. These steps include:

1. Scope the work and fill in the job safety analysis form (JSA).
2. Attach relevant work permits.
3. Include any supporting documents.
4. Return the work pack to your Watercare representative.

A complete list of requirements and instructions can be found on Watercare's website under Control of Work System.

The minimum health and safety requirements set out by Watercare must be adhered to and the documentation and procedures must be of an acceptable standard which:

- Describes the procedures to assure compliance with systems, good practice and legislation.
- Provides information to demonstrate that the Health and Safety Management System is capable of managing specific hazards and meeting Watercare minimum requirements. Regulations, approved codes of practice and industry standards or guidelines should be referenced as the basis for hazard controls.
- Provides a Health and Safety Management Plan which addresses controls and unique high-risk activities or components of the work.
- Demonstrates the proposed risk controls are adequate and identify alternatives to further reduce risk. Where administrative controls are used, it must be demonstrated that these are sufficient, robust and how they will be properly managed.
- Provides the names of Health and Safety staff and their responsibilities.
- Verifies that all workers have received adequate training for managing the hazards and risks and undertaking the work safely.
- Conducts and record site specific inductions.

Below is a list of documents and forms generally required as part of the Control Work System:

Risk assessment documents and forms

- Job safety analysis (JSA) – template.
- Job safety analysis – user guide
- Access authority (AA) – template.
- Access authority – user guide

Permit to work

- Permit to work – process
- Permit to work – decision trees

Permits

The Contractor is responsible for obtaining all necessary permits, approvals and licenses (including cost associated with obtaining such permits, approvals and licenses) that are required for the proposed works. The following permits shall be acquired as necessary to carry out the rehabilitation works:

- Working at height
- Safety device impairment
- Confined space
- Excavations
- Explosive atmosphere area
- Hazardous energy
- Hot work
- High risk activity

Forms

- Isolation certificate

Where work is on an existing Watercare facility or asset an Access Authority is required before work can start.

Refer to Watercare's Standard for Health and Safety and Environmental practice (HSE) for a more detailed breakdown of requirements.

5.1.3 Work method statement

The Contractor shall submit a Work Method Statement (WMS) prior to construction for review by Watercare. This shall clearly define the proposed delivery is in conformance with the requirements of the contract documents. The WMS shall at a minimum include the following:

- Health and Safety management plan.
- Clearly indicate that the selected technique will conform to the project requirements and specifications.
- The scope of work including a detailed installation plan describing all preparation work, cleaning operations, pre-CCTV inspections, bypass pumping, traffic control, installation procedure, method of installation, warrantees to be provided and all else necessary and appropriate for a complete installation.

- A detailed installation schedule shall be prepared and submitted, conforming to the project requirements.

- A description of the proposed rehabilitation technique, including a detailed plan for identifying all active service connections (where applicable), maintaining service to affected properties during installation, including temporary service if required.

- A description of the lining materials to be used for the project. Materials should be fully detailed in the submittals and conform to the project specifications and/or shall conform to the pre-approved products listed in this document.

- A statement of the Contractor's experience: The Contractor's personnel and/or Subcontractors shall be able to demonstrate that they have successfully completed similar or larger scale projects using the specified lining material.

Note: Where manufacturers provide training and certify Contractors to install liners, the Contractors or subcontractors must have the relevant certification.

- Engineering design calculations – The Contractor will submit drawings defining the liner dimensions and design calculations certified by a chartered professional engineer. A Watercare Compliance Statement shall be completed to document this.

- The manufacturers data sheets and installation requirements shall be submitted for all products.

- Submittals shall include information on the liner profile for the intended for installation and all tools and equipment required for a complete installation. The WMS shall identify which tools, and equipment will be redundant (spares) on the job site in the event of equipment breakdown. All equipment, for the project, including proposed back-up equipment, shall be clearly described. The Contractor shall outline the mitigation procedure to be implemented in the event of key equipment failure during the installation process.

- A description of the Contractor's proposed procedures for removal of anticipated obstructions/debris in the pipeline that may be encountered during the cleaning process.

- A detailed stakeholder management plan shall be prepared and submitted if applicable. Public outreach and ongoing interaction (communications, updates, notices of planned works etc.) may be required as part of Contractor's responsibilities.

- An odour control plan shall be submitted by the Contractor indicating how odours will be minimised at the project site and surrounding area, if applicable.

- Work plan including the proposed programme of works, work sequence (e.g. establishment, set-out of equipment, lining), duration, points of entry and exit, means of ventilation, and staging area.

- The Contractor shall outline any specific repair or replacement procedures for potential defects that may occur during the installation. Repair/ replacement procedures, if any, shall be as per the manufacturer's recommendation.

5.1.4 Flow management

Ideally, the most suitable installation conditions of the selected rehabilitation method should be prioritised, thereby not limiting the choice of liner. In practice, however in-line rehabilitation methods are often necessary for large transmission sewers as diversion may not be possible.

The Contractor shall provide a Flow Management Plan (FMP) to accommodate pipe flow for any sections around which flow is to be held back and diverted for the works.

The FMP shall include contingency provisions for the following:

- Failure of equipment.
- Power supply failures.
- Installation delays in excess of available storage time using upstream facilities.
- Full or partial blockage or failure of bypass pumping equipment (pump or hoses).
- Flow from any major source or industry upstream increasing rapidly.
- Increased flows caused by high intensity rainfall, including early warning monitoring and site alert / standdown plans.
- Failure of a sewer plug.
- Failure of equipment or power supplies, or other components of the flow management facilities.
- A major failure at any downstream pumping station which causes flow to back up in the sewers.
- Manage risk to people, environment and work quality.
- Any other likely cause of high flows or sewer levels in the specific location.
- Upstream monitoring confirming no overflows.

The FMP and the Project Programme shall allow for each bypass operation to be in service for an agreed trial period before any of the works in the pipeline proceed. Details of each flow diversion operation shall be submitted for approval to Watercare and shall be approved before each flow diversion commences. Watercare shall have the final decision as to when and whether a diversion operation shall commence. The Contractor shall make reasonable allowance for inability to work during periods of inclement weather and high intensity rainfall.

By-pass pumping must be undertaken either by the Contractor or by an approved specialist sub-Contractor.

Approval of the FMP shall not relieve the Contractor of their responsibilities to ensure that sufficient and adequate pumping or other flow arrangements are provided at all times to maintain system operation.

Note: Unless approved by Watercare, the Contractor shall not commence works or stages of Work until the Flow Management Plan has been accepted.

5.1.4.1 Planning

For the purposes of planning the order of works, including any by-pass pumping, all by-pass pumping systems must have the capacity to pump up to and including the Peak Wet Weather Flow (PWWF). Flow data (hydrographs) will be provided by Watercare for pipelines greater than DN 300 to allow for system management and storage requirements.

The Contractor must verify flows at site prior to undertaking works, and before selecting a bypass pump. Modelled flows can vary from actual flows, due to modelling uncertainty and the variable nature of catchment behaviour.

For planning purposes, the Contractor can obtain indicative information such as manhole cover and invert levels and distances between manholes from Watercare's online GIS viewer, however these must be verified on site.

Watercare may nominate specific pumping and discharge manholes.

Prior to arranging for the set-up of bypass pumps at a particular site, the Contractor must provide Watercare with design calculations, nominated pump-sets and work method statements for approval.

The Contractor must ensure all required consultation, permits, approvals, notifications, quality plans, safety plans (including public safety at manholes), traffic management plans etc. have been completed prior to setting up any by-pass pumping.

Note: During the lining operation, minor flows, which do not prevent the liner installation from proceeding, may be allowed to continue, provided that the flow is screened to prevent silt, rags or other debris from moving into the pipe section under repair after it has been cleaned. The extent of flow allowance shall be confirmed with the Contractor and specialist liner installation sub-Contractor if relevant.

5.1.4.2 Bypass capacity and sewer protection

When flow in the main and connecting sewers is plugged, blocked, or bypassed, sufficient precaution shall be taken to protect all upstream pipes from surcharging and / or damage.

Precautions shall be taken to ensure that control operations do not cause sewer overflow, flooding, or other damage to public or private properties.

The Contractor must ensure that surcharges or overflows of the sewer as a result of lack of capacity in the main sewer diversion system do not occur under any circumstances. It will be the

Contractor's responsibility to assess the flow in each line and to ensure that all plant and equipment used for the temporary diversion of flows is adequate for the required duties.

If the diversion capacity is exceeded by flow in the pipeline, the Contractor shall either:

- Cease work at the earliest possible time and reinstate flow to the main and connecting sewers; or
- Continue to work by increasing the diversion system capacity to match the higher actual or anticipated flow.

The Contractor will be responsible for immediate notification to Watercare in the event of any overflow or surcharge. The Contractor shall clean up, decontaminate and restore the area affected to the satisfaction of Watercare with any and all fines and/or punitive actions, (if applicable), being borne by the Contractor.

5.1.4.3 Bypass pumping

Where required, the Contractor shall set up pumps and hose or pipeline routes with the capacity to maintain the wastewater service to all the properties within the catchment. Where hose or pipeline routes cross roads, access ways etc, the Contractor shall make all necessary arrangements for continued vehicle access with property owners and occupiers and obtain all necessary permits from local authorities.

The Contractor must ensure that all by-pass pumping discharge lines are a minimum of DN150mm. The discharge pipes must be sized correctly for the specific length and head conditions. They must be of a type that has no leakage at any joint or any other part of the pipe. Pipes must not be hung to avoid obstacles or roads. The Contractor must plan the most appropriate route for submission to and approval by Watercare. It may be necessary to construct a rising main in a trench at road crossings. In such cases, covering structures to enable traffic flow will be in accordance with the roading authority's requirements.

Where properties cannot readily be served by the bypass pumping arrangements, suitable provision shall be made to hold back flow or other suitable means to maintain wastewater service.

5.1.4.4 Standby pumps and equipment

At all times during the period of bypass pumping, the Contractor shall have standby pumps kept on site, sufficient to maintain the full bypass pumping requirement. Standby pumps shall be capable of full operation independent of primary pump power sources. Additional pipelines, hoses, and fittings shall be available on site to provide for any pipeline failure during a bypass operation, and to meet all flow management contingency plans.

5.1.4.5 Supervision of pumps

The Contractor must ensure that a specialist full-time, qualified mechanic/fitter is on site to supervise operating by-pass pumps and minimise the risk of pump stoppage.

The Contractor must ensure that in the event of a by-pass pumping breakdown or stoppage, any sewer plugs, or control devices are removed to allow the sewage flow to pass though the existing sewerage system without pumping.

Any costs incurred by the Contractor, associated with the removal and replacement of sewer plugs or costs associated with damage or loss of production, which result from by-pass pumping failure, will be borne by the Contractor.

By-pass pumps shall be silenced below the permissible ambient noise levels and have support personnel to prevent any failure and possibility of sewage overflow. The bypass pumping arrangement must not be left unattended until the sewer has been returned to normal operating condition.

5.1.4.6 Works downstream from plugged lines

The Contractor shall take particular care to secure in place any pipe plugs that are required for bypass pumping or for flow retention. The Contractor shall be responsible for the repair of any damage caused to any liner by the dislodgement of any plug or leakage from any plugged pipeline.

5.1.4.7 Flow management contingency plans

The following contingencies need to be provisioned for:

- Full or partial blockage or failure of bypass pumping equipment (pump or hoses).
- Failure of a pipe plug.
- Flow from any major source upstream increasing rapidly.
- Any other likely cause of high flows or flow levels in the specific location.

The Contractor's Health and Safety Management Plan shall recognise and make provision for these events.

5.1.5 Quality control plan

A detailed Quality Control Plan (QCP) shall be submitted to Watercare before the commencement of any work, which fully represents and conforms to the requirements of the *Project Specification* and this document. This will be used to ensure that written records, still photographs, video files and other records are gathered as required to demonstrate that the Contractor has completed the installation, and it is compliant with the minimum requirements. At a minimum the QCP shall include the following:

- Defined responsibilities, of the Contractor’s personnel, for assuring that all quality requirements are met. These shall be assigned by the Contractor to specific personnel.
- Copies of all liner strength properties design calculations, with an authored CS1 (Design) compliance statement for all calculations.
- Proposed procedures for quality control, joints sealing, assembly operations, product sampling and testing shall be defined and submitted as part of the plan.
- Proposed methods for product performance, controls, including method and frequency of product sampling and testing both in raw material form and installed product form.
- Scheduled performance and product test result reviews between the Contractor and Watercare during scheduled meetings.

- Inspection and testing plan documenting all quality control hold-points, witnessing of works and sign-off, demonstrating compliance with the *Project Specifications* and performance requirements.

5.1.6 Pre-condition survey

The Contractor shall conduct a pre-condition survey of the site before the commencement of any works. This shall document the existing condition and used as a baseline when reinstating the site (see Section 6.4).

5.1.7 Cleaning and preparation of the pipeline

Cleaning and preparation of the pipeline may involve:

- Waterblast cleaning the sewer using hydraulically powered equipment and jet cleaning.
- Mechanical scraping of the pipeline to remove embedded material or tuberculation (dependent on material properties and condition of host pipe).
- Remote / robotic mechanical removal techniques for removing protrusions (e.g. robotic camera operated system used to open laterals).
- Waterblast scabbling at manhole entry / exit to prepare for epoxy mortar sealing.

Note: Mechanical scraping is not allowed on asbestos cement (AC) host pipes.

Cleaning must be carried out from the downstream manhole and must remove all grease, slime and loose material from the pipe bore and manhole.

All loosened and inherent silt and grease material in the pipe to be rehabilitated must be prevented from passing downstream.

All mass roots shall be neatly cut off flush with the internal surface of the sewer using a remotely controlled water jet cutter or other approved technique and shall be monitored by CCTV to avoid host pipe damage.

All intruding property branch sewer connections shall be neatly cut off flush with the internal surface of the sewer using a remotely controlled robotic cutter or other approved technique and shall be monitored by CCTV.

Debris and other matter cleaned from the sewers and manholes shall be trapped in the downstream manhole, removed and disposed appropriately and in accordance with all relevant regulations. The Contractor shall not leave debris and other matter on site.

Additional cleaning of build-up of material in the sewer main to ensure a satisfactory level of cleanliness, may be undertaken at the approval of Watercare.

The Contractor shall confirm which property connection laterals are live prior to lining. Where necessary, the Contractor shall liaise with Watercare and/or undertake dye testing through the property lateral.

Note: The Contractor shall provide separate rates for standard and additional (heavy) cleaning: e.g. Mechanical cleaning to remove debris or scale more than 25% of the host pipe's internal diameter.

For main sewers, all internal debris and protrusions that will interfere with the installation or adversely affect the performance of the liner shall be removed from the original pipe.

For both pipes and laterals, all other protrusions or sharp-edged obstructions which may obstruct the liner installation, or cause damage to the liner during or after installation shall also be removed.

This may include mortar, stabilised debris, concrete washings in the invert and infiltration build-up.

Prior to installation, any other conditions that may prevent the proper installation of the liner or affect the structural and hydraulic integrity of the finished liner - such as collapsed sections, offset / displaced joints, running infiltration, dips - shall be assessed by the design engineer to determine the effect this may have on the performance of the pipe post lining. Based on the assessment and recommendation of the design engineer, rectification may be required and may involve:

- Localised patch repairs to sections of the host pipe.
- Installing local no-dig spot repairs (NDSRs) to stabilise defects in specific locations.
- Installing a pre-liner to restrict circumferential stretching of the liner, and/or to smooth transitions at displaced joints.
- Excavating to repair non-conforming localised defect or facilitate installation of the liner.

5.1.8 Additional Sewer Main Cleaning

All sewer mains shall be cleaned by a non-destructive method as approved by Watercare to enable a precise and successful Condition Assessment and undertake Rehabilitation and/or Repair works (where applicable).

Where an obstruction, heavy deposits or the poor structural integrity of the sewer main prohibits successful cleaning to be performed, the Contractor may be directed by Watercare to employ an alternative methodology.

The alternative methodology may involve:

- Greater than three (3) cleaning runs.
- Robotic cutting.
- Robotic grinding.
- Chain flail.

Note: Unless immediate additional sewer main cleaning works are required to mitigate a possible spill from the sewerage system, the Contractor must obtain approval from Watercare prior to commencing any additional sewer main cleaning.

5.1.9 Disposal of excavated and retrieved material from pipe cleaning

Material excavated in the process of establishing temporary works or liner insertion shall be dewatered and stockpiled in an area which prevents contamination and is secure from public access. Alternatively, it may be removed from the site to a disposal site approved by the Engineer.

Contaminated solid material and groundwater (if any) produced from cleaning the pipe or any of the manholes, or from any other activity on the site shall be removed from the site in suitable leak-proof vehicles or containers, to avoid contamination of any private or public property.

Contaminated material shall be disposed of at a suitably licensed landfill and shall not be stockpiled on the site.

5.1.10 CCTV Inspections

The CCTV inspections shall be carried out in compliance with the latest revision of the New Zealand Gravity Pipe Inspection Manual (NZGPIM), and Watercare CCTV Data Provision Requirements.

The Contractor shall carry out a CCTV inspection of each section of the cleaned sewer immediately prior to commencing the liner insertion process, to confirm:

- That the pipeline section has been cleaned to a satisfactory standard.
- The length of the pipe from manhole to manhole.
- Location of changes in direction including bends and junctions.
- Location of changes in diameter.
- Location of fittings and inspection points.
- The location of any conditions or deformities that may prevent the correct installation of the liner including:
  - Encrustation, deposits and contamination.
  - Obstructions affecting the cross-section.
  - Deformation of cross-section.
  - Defective joints.

This inspection shall be carried out in a pipe with no flow, and from which any standing water has been removed. Inspection records shall also be submitted to Watercare for review, with no further lining preparatory work to proceed until Watercare is satisfied with the standard of cleaning.

5.1.11 Manhole condition assessment

As part of the condition assessment requirements, the Contractor shall complete an assessment of all manholes or access points for the respective sewer mains.

The assessment shall identify and record:

- Manhole type, location, dimensions and configuration.

- Manhole furniture (ladders, platforms, internal droppers, etc.).
- Types and locations of defects including infiltration, cracks and fractures, corrosion, damage, etc.
- Estimated remaining wall thickness of access points.

The Contractor shall submit an assessment report detailing the condition of each manhole / access point inspected. The format and specific content of sewer access point condition reports will be agreed with Watercare. All electronic condition and geometric survey data shall be provided to Watercare in the required format.

Evidence from the inspections shall be used to assess the condition of access points to determine any requirements for rectification works, including removal, and/or replacement of furniture within the manhole.

The scope of remediation works to manholes or access structures shall be agreed with Watercare.

Removal and reinstatement of the manhole furniture as required to complete works and making good of furniture penetrations and connections shall be included in scope. The methodology for this work shall be proposed by Contractor and agreed and approved by Watercare prior to the work being carried out.

5.1.12 Confirming liner size(s)

To ensure conformance to design parameters and that proper fit of the liner is achieved, the Contractor shall be responsible for measuring the internal diameter throughout the existing pipelines. This shall include measurement of the horizontal and vertical alignment at changes in direction and bends.

Note: Change in direction is generally accommodated with a manhole.

Where person-entry is not preferred or permitted, the dimensions of the pipeline shall be confirmed using laser profiling or similar digital technique.

This shall be completed prior to the lining material being ordered. The Contractor shall document the location and sizes of all variances in diameter, lateral connections, and any protrusions and deformations and shall provide geometric survey data to Watercare in the required format.

The selected liner shall be sized within the allowable tolerances specified in the *Project Specification* to meet both structural and hydraulic requirements.

5.1.13 Pipeline preparation after cleaning

Where preparatory cleaning and inspection reveals substantial defects in the pipe wall, which are likely to cause excessive deformation or other damage to the permanent lining, preliminary patching of hole(s) or other appropriate repair will be required. The repair of any damage, caused by the cleaning equipment, shall be the responsibility of the Contractor.

The form and method of carrying out any such preliminary repair shall be in-line with the Contractor's Work Method Statement and shall be agreed with Watercare before the installation of the liner proceeds.

Where there are abrupt discontinuities in the cleaned pipeline, and these may adversely affect the installation or performance of the lining, the discontinuities shall be renovated by installing a suitable patch repair compatible with the liner materials and the host pipe and shall have a design life matching the liner. This material shall be resistant to external exposure to soil bacteria and any chemical attack that may be due to residues remaining on the pipe wall, products from degradation of the existing pipe, components of the lining system, or elements in the surrounding ground. The Material in its fully cured state shall be permanently resistant to softening in the installed location.

The infilling material or preliminary patch repair material shall be sufficiently cured before installation of the main liner so that it is not displaced or compressed by the lining process.

Where the pipe is too small to enable discontinuities to be infilled with mortar, alternative methods of remediation including sleeving or excavation, and realignment may be required.

5.2 Installation

5.2.1 On-site storage of materials

The Contractor shall only store sufficient materials on site as are necessary to allow timely and efficient progress of the work.

Stockpiles of excavated or imported material shall be stored where they cause no interference to the public, drainage routes or vehicular or pedestrian traffic.

Clear lines of sight for drivers must not be obstructed. Materials shall not be stacked against structures, fences, trees or other property improvements.

Pipes shall not be dragged across sharp or abrasive surfaces or subjected to rough usage resulting in excessive damage.

Soft strops are preferred for pipe lifting, but when wire ropes or chains are employed, pipes shall be suitably protected against scoring.

Pipes with end treatment such as flanging or preassembled fittings shall be stacked or supported so that the ends are free from carrying any loading

5.2.2 Liner installation

Refer to Watercare's method specific performance specification guidelines for installation requirements.

5.2.3 Launch and reception points

Where possible, existing manholes shall be utilised as launch and reception points. New manholes required to complete the lining shall be approved by Watercare before being constructed.

The Contractor shall reinstate all manholes to Watercare standards, such that installed liners do not form irregularities around the edges of manholes. After installation of liners, the Contractor shall ensure benching and channelling in the manholes are free from any irregularities or

differences in level which may cause accumulation of solids (i.e. debris, silt, rags, etc.) in the sewer or manhole channel.

Where liners have been installed and terminate at the upstream and downstream ends of manhole, the channel shall be rendered to form smooth slope between liner inverts to prevent accumulation of silt or debris near the liner edge.

The Contractor shall replace any internal drops within manholes that are damaged as a result of the rehabilitation works.

Where necessary, the channel benching and walls of the manholes may be altered to receive the lining. Details of proposed alterations shall be submitted to Watercare for approval. No alterations shall be carried out until the proposal has been approved by Watercare. All manhole alterations shall be made good following the completion of the lining. Photographic evidence of reinstatement work within manholes shall be retained by the Contractor and made available to Watercare as part of the quality assurance documentation.

5.2.4 Lining through the base of manholes

Where upstream and downstream sewers from a manhole are both to be lined, the design may include lining of the manhole channel (or chase). The liner in the channel shall be neatly cut over the pipe entry and exit and be between 10 – 15 mm above springing level. The space between the extensions above the spring level and the existing benching shall be rendered to achieve smooth transition, with no areas prone to silt collection. The Contractor shall ensure that there is a satisfactory bond between the added epoxy mortar and the existing benching.

The Contractor shall adjust manhole benching and bases to accommodate linings to ensure a continuous invert without steps between the lining and the upstream or downstream sewers.

5.2.5 Lateral connections (where applicable)

Prior to lining any pipe section, the status of all lateral connections in the pipe section shall be determined, by dye testing or other appropriate methods.

The Contractor must clear the junction of any roots and obstructions that may cause a blockage and remove any roots, debris, silt, etc. to leave a clean and smooth-edged junction, free of any obstructions up to and including the first joint in the property connection sewer from the reticulation or branch sewer.

Defective public lateral connections causing infiltration shall be repaired. The Contractor shall inspect the lateral pipe up to the property boundary (or where the public lateral transitions to the private ownership) for defects and provide details to Watercare of the assessment and recommendations, including methods of repair (if required). Based on the findings, Watercare may choose to rehabilitate the lateral – the scope of lateral rehabilitation shall be agreed with the Contractor.

The Contractor must make all necessary arrangements to ensure that affected lateral connections are not in use during the lining operation. This is to prevent entry of debris into the host pipe during the lining operation but also prevent backflow and overflow at properties when laterals are temporarily sealed off during rehabilitation of the main line.

The Contractor is required to identify and notify all affected properties and provide the necessary sewer service to minimise disruption during lining works. The Contractor shall advise Watercare of any arrangements made to comply with this requirement. After lining is complete, lateral connections shall be re-opened within 12 hours of disconnection, at least sufficiently to provide for sewer service to be re-established.

Unless it can be clearly established that the connections have been abandoned, all live connections are required to be reinstated (opened) on rehabilitated sewer mains. Where internal remote-controlled cutting equipment is used (e.g. ball grinder) to reinstate live connections within the rehabilitated sewer main. The Contractor shall ensure that each hole cut by this equipment or otherwise reinstated, will not inhibit flow into Watercare's main pipeline from the connection, or cause any constrictions that may catch solid material and cause a blockage.

The cutting equipment used shall be capable of opening the liner aperture for wye or tee connections and leaving a smooth edge with no ridging or snags. The cut-out shall be flush with the projected surface of the lateral for which it is required. Cutting errors within the tolerance of +15 mm – 0 mm at lateral openings will be allowed if the lateral junction repair (LJR) system proposed will cover the overcut.

The Contractor must have auditable processes for checking and confirming all live connections have been cut out and will be liable for any costs incurred resulting from failure to adequately cut out a live connection.

If a dead lateral connection is re-opened in error, it will be re-sealed at no additional cost using a methodology approved by Watercare.

5.2.5.1 Lateral junction repairs (LJR's)

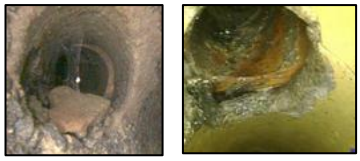
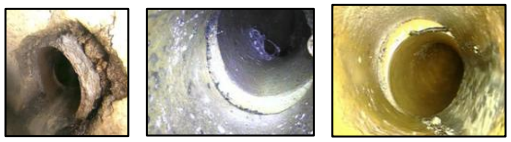
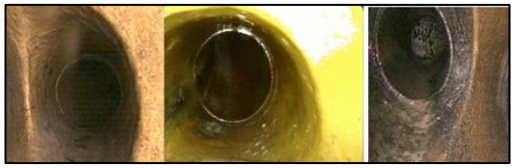
Following the CCTV inspection prior to renewal, the Contractor shall determine if the lateral junctions on the main line can be sealed using an LJR. Damage to the lateral may require repair prior to lining or LJR installation. This shall generally be required where:

- There is evidence of excessive root intrusion between the junction and the main sewer
- It's evident that the lateral junction has been structurally compromised
- There is soil visible around the junction entry

The alignment of some knock-in lateral installations, the presence of bends close to the first joint and lateral connections close to the sewer main within the lateral may also prevent installation of LJR's. These shall be identified prior to lining and a suitable methodology for repair or sealing shall be accepted by Watercare prior to lining.

***Table 2**: Example illustrations evaluating lateral junction repairs.*

Lateral junction condition	Example	Action
Root intrusion		Repair required

Lateral junction condition	Example	Action
Structurally compromised		Repair required
Displacement around junction (soil visible)		Repair required
Structurally sound		No repair required

Where lateral junction repairs are installed, this shall be carried out in accordance with *ASTM F2561: Standard practice for rehabilitation of a sewer service lateral and its connection to the main using a one piece main and lateral cured-in-place liner*.

Alternative lateral junction repair methods may be proposed by the Contractor which may include thermoplastic or other suitable components compatible with the liner material installed. This must be agreed with Watercare, before any work is carried out.

NOTE: ASTM F2561 references several complementing standards; one of which is ASTM F1216. The ASTM F1216 standard is referenced for purposes of tube design considerations for a CIPP liner. ASTM F1216 is not an applicable standard for the sealing of lateral connections where the lateral CIPP forms a verifiable non-leaking connection to the mainline. ASTM F2561 is the industry standard for renewing lateral pipes and main/lateral connections using full-hoop CIPP liners and pre-moulded compression gaskets.

LJR's must completely cover the cut edges of the lateral service aperture and overlap the liner by at least 50mm beyond the cut edges. The extension of the LJR upstream into the lateral shall extend at least 150mm past the first upstream joint in the pipe.

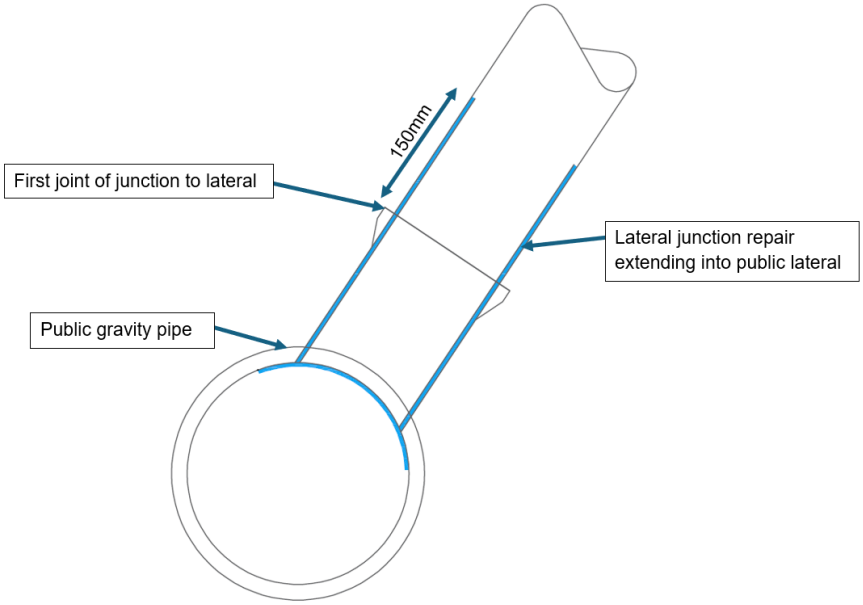


***Figure 1**: Extent of LJR into public lateral connection*

If this is not feasible, subject to approval by Watercare, connections may be re-opened by excavation for an appropriate lateral junction repair.

If laterals are installed or re-connected by excavation, an approved saddle connection shall be fitted between the lateral and the lining material in the main sewer.

The sealing systems shall have the following properties:

- Compatible with the sewer main liner, property service connection and any other surfaces or conditions present so as to ensure a sealed bond with, and no deleterious effects on, these surfaces or conditions.
- Provide a watertight seal against infiltration, exfiltration and tree root intrusion.
- Ensure smooth transitions free of constrictions or defects that may decrease hydraulic efficiency, cause a blockage or otherwise inhibit flows across the sealing system.
- Be sufficiently robust to withstand pipe cleaning equipment that may be required to remove any future blockage.
- Bevel edges where it transitions to the junction, providing smooth corners.

5.2.6 Patch repairs

Where patch repairs are required, they shall conform with or be compatible with all relevant requirements of full-length lining system.

Patch repairs shall extend a distance of 300mm past the upstream and downstream limit of the defect that they are intended to address.

The ends of the repair shall be tapered to ensure they do not reduce hydraulic performance or cause a build-up of debris or blockage.

5.2.7 Excavation

Where additional excavation is necessary the Contractor must detail the steps, it has taken and points it has considered when seeking approval for the work to commence.

5.2.8 Grouting of pipes (where applicable)

Grouting of the annulus between the liner and the host pipe will generally not be required for smaller pipes, however if it is required, then this will be specified in the *Project Specification*. In some cases, even though grouting has not been specified, it may be required to satisfy structural design requirements.

5.2.8.1 Grouting methods and techniques

Where grouting is specified in the design, the grouting materials and techniques shall:

- Allow grouting to proceed with the clearances provided by in the design.
- Provide an inert filler, which will resist attack from the sewage and ground water, fill all the voids between the liner and the sewer walls and provide structural action consistent with the assumptions made in the structural design. Cement based grouts shall be resistant to hydrogen sulphide (H_2S).
- Prevent the flow of sewage behind the liner should any failure of the liner or joint occur.
- Restrict the liner against any vibration or deflection which may be caused by high flows.
- Not adversely affect the liner as a result of hydration temperatures whilst the grout cures.

A multi-stage grouting system may be required in order to secure the installed liners against movement and avoid the contamination of the grouting space by sewage as well as limiting loads and pressures.

5.2.8.2 Grouting pressure

Should the proposed rehabilitation method require annulus grouting, flotation or deflection of the liner due to pressure induced by the grouting shall be prevented. The proposed method for pressure injection of grout fluid shall be within the defined acceptable limits of the liner manufacturer. If the liner is not able to withstand the proposed grout pressures, then the maximum pressure at the point of grout injection must be reduced or staged grouting must be employed.

5.2.8.3 Submission of grouting details

The Contractor must submit full details of any grouting proposed to Watercare with the design. This shall include technical data on characteristics and performance of the grouting materials to be used, the construction techniques, spacing of injection points and method of verifying successful installation of grout.

At completion of any grouting operation, the Contractor is required to provide Watercare with grout log sheets showing the quantity and type of grout injected for each sewer line.

5.2.9 End termination at manholes and chambers

After lining, ensure that liners are flush with manhole and chamber inside walls or as flush as practically possible. Seal all end terminations at manholes and chambers by filing the residual annular space with a suitable grade of epoxy mortar to prevent infiltration under the maximum expected groundwater conditions.

The epoxy mortar material shall be compatible with the liner materials and the host pipe and will have a design life matching the liner. Smooth the transition between the manhole or chamber entry or exit and the liner end shall be smoothed to minimise any level differences or other irregularities that may cause debris, silt, rags, and similar materials to accumulate.

Ultra-high pressure water blasting may be required to scabble the pipe entry and exit before placing the mortar to provide a satisfactory bound between the mortar and manhole entry / exit.

Note: All sealing materials shall be installed in accordance with the manufacturer's specifications, including all preparation works and application of the product.

5.2.10 Defects

Liner imperfections beyond allowable tolerances and which adversely affect the operation of the renovated pipeline are considered defects.

The installed liner shall be free of all defects which affect hydraulic or structural performance of the renovated pipeline. This includes defects arising from substandard materials, faulty or inaccurate manufacture, inadequate pipe preparation, faulty installation or workmanship, or inadequate curing.

The Contractor shall specifically define all repairable defects that may occur in the installed liner based on manufacturer's recommendations, including a detailed step-by-step repair procedure, resulting in a finished product meeting the requirements of the *Project Specification*. This shall be documented in the Contractor's Work Method Statement.

The Contractor shall specifically define all unrepairable defects that may occur, including a recommended procedure for the removal and replacement of the liner. This shall be documented in the Contractor's Work Method Statement.

Irregularities shall be assessed based on the guidance provided in Appendix D, Notes on Identifying Latent Defects and Features in Lined Pipe within the latest edition of the NZ Gravity Pipe Inspection Manual to determine whether it should be categorised as defect.

In addition, Watercare's method specific performance specification guidelines and Guidelines for As-Built CCTV Inspection of Lined / Rehabilitated can also be referenced to assess irregularities.

5.2.11 Identification tags

The Contractor shall mark all sewers that have been lined as part of the rehabilitation works.

The Contractor will supply an engraved / lasered stainless-steel identification tag approved by Watercare to be fastened above the crown of the pipe, against the manhole without causing any risk of damage to the manhole. This shall be installed in both the upstream and downstream manhole of the sewer that has been rehabilitated.

The identification tag shall have the following information engraved as a minimum:

- Date (month and year if installation)
- Liner material
- Installed (Upstream, Downstream)
- Liner installer
- Maximum allowed cleaning pressure for liner type installed

All equipment used for the installation of the identification tag, shall be intrinsically safe.

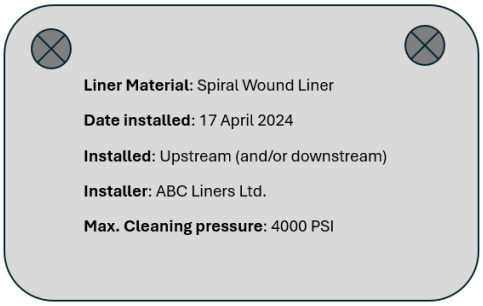


Figure 2: *Tag illustration example*

6. Acceptance Control

The completed liner shall be assessed by Watercare or a nominated third party on behalf of Watercare to confirm that the installed liner meets the requirements of the *Project Specification*. It is expected that this review will be completed within two weeks of the work being completed.

This assessment will involve a review of the following items (as a minimum):

- Pre- and post-lining CCTV footage and log sheets
- Testing and sampling records (note this may take up to 8 weeks, so the Contractor shall ensure the required testing is completed in advance of the final submission of documentation)
- Photographs of completed laterals and end terminations at manholes or chambers.
- Records/notes of visual inspections
- Completed inspection and testing plans and supporting documents.
- Quality assurance documentation
- Material data sheets for all materials used in the lining process.
- Marked up drawings to show the as-built works

- Sampling records and certificates of test results
- Details of any remedial works undertaken

6.1 Post-rehabilitation CCTV inspection

A post-rehabilitation CCTV inspection shall be undertaken for all liners in mainlines and laterals (including DN100 laterals) once all works have been completed. The CCTV inspection shall be in accordance with the latest revision of the New Zealand Gravity Pipe Inspection Manual.

During CCTV inspection, water flow depths less than 25% of the pipe diameter are acceptable if it does not obscure a clear view of the invert of the pipe.
Where the depth of the water in the pipeline exceeds 25%, or the view of the pipe is obscured by the flow, water level in the pipe shall be reduced or removed. This may involve the following:

- Returning at an off-peak time when the flow rates have reduced. Off-peak times vary according to location and use of the pipeline, but in general this would be between 10am–3pm and after 9pm.
- Controlling (limiting) the flow or by-pass pumping around the pipeline being inspected.
- Flushing the water from a dip in the pipe by pulling a jetting nozzle through the line immediately in front of the CCTV camera. When flushing water from the pipe, the jetting unit shall be set up at the downstream node, flushing the water downstream towards it.

Flows from live laterals into the pipe being surveyed should result in a flow in the pipe no more than 10 mm deep so that the full circumference of the pipe is visible. Ensure that visual evidence (i.e. CCTV footage and / or photo) is captured for the seal of the liner at both the upstream and downstream manholes or chambers. A pan and tilt (radial view) camera shall be used.

The finished liner shall be continuous over the entire length of the installation and shall be free of significant visual defects, damage, deflection, holes, leaks or other defects. Evaluation and acceptance of defects shall be as per Table E 3.4.3 of NZGPIM. Engineering assessment of the defects shall be submitted to Watercare for approval. Any defects outside the acceptable limits, or where the Engineering Assessment is not approved by Watercare, shall be repaired or replaced.

Unedited digital documentation of the inspection shall be provided to Watercare within ten (10) working days of the liner installation. The data shall note the pipe size, manhole ID, inspection date, location of all reconnected laterals, debris as well as any other defects in the liner, including but not limited to gouges, popped locks, cracks, bumps or bulges

The inspection shall also provide clear visual evidence that the sealing of the end termination is acceptable.

A final CCTV inspection shall also be carried out before the end of the defect's liability period, post installation to confirm the condition of the liner and any further remedial work.

Note: There shall be no power interruptions or "blink-outs" during any video inspection which will be continuous, with the full circumference of the pipe being clearly visible.

6.2 Leak testing

Pipe shape, size, lining material and the presence of lateral connections can limit the application of and available leak test methods.

The general recommended approach retains the ability to undertake leakage testing where it makes:

1. Practical sense to undertake, and
2. Where there are defects, and that the testing is expected to give results with some confidence post repair.

It also recognises that defects such pinhole leakage, defective LRJ's and end seals will not be identified from initial CCTV inspection or leakage tests and requires further visual inspections to identify these (and repair them) before the project is fully complete (before the end of the Defects Liability Period).

Where liners have been installed in pipes without lateral connections, the required leak testing shall be carried out at a frequency nominated in the *Project Specification*. This will be dependent on the Flow Management Plan and size and shape of the liner. At a minimum 10% of the total installed liner length for the project shall be tested following installation.

Where lateral connections are located along the lining system the approach shall be as follows:

1. The Contractor shall carry out a CCTV inspection immediately after lining installation and prior to opening of laterals.
2. If any defects are identified, the necessary repairs as outlined in the Contractor's Work Method Statement shall be carried out to address all defects.
3. The Contractor can elect to carry out a leakage test prior to opening the laterals (refer to Table 3 for applicable methods).

Note: The leakage test shall be videoed and kept on file as evidence of the test.

4. Should the Contractor elect not to carry out a leak test, it is to be understood that liner will be monitored and assessed for defects by Watercare or Watercare's representative upon receival of the CCTV footage and at the end of the defect's liability period for any leakage.
5. The CCTV results reviewed by Watercare or Watercare's representative shall be recorded in the Contract quality assurance documentation.
6. If leaks are observed, the Contractor shall rectify the issue as an outstanding defect at no additional cost to Watercare.

Figure 3 outlines the proposed process.

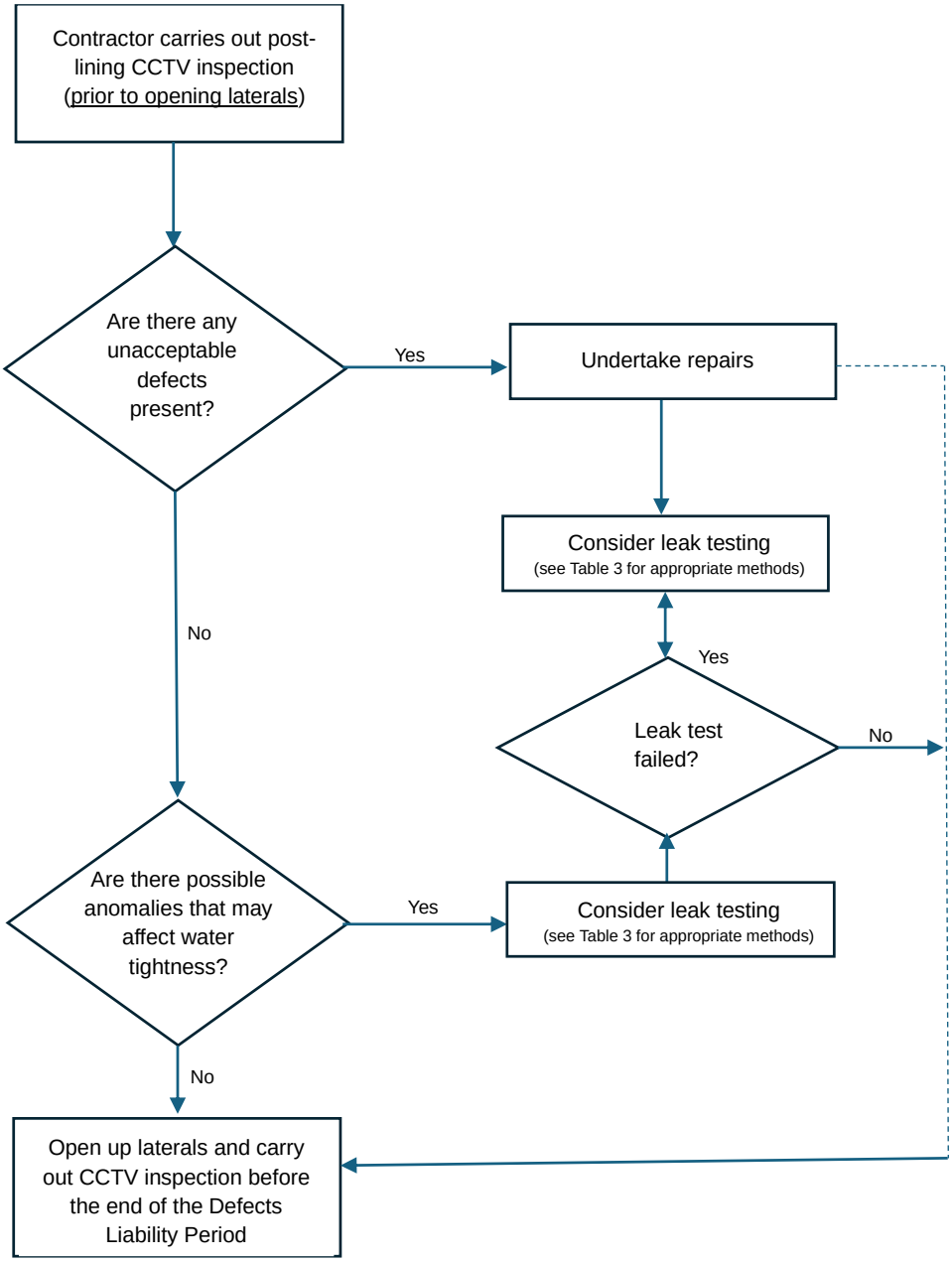


***Figure 3**: Decision process for leak testing*

***Table 3**: Summary of leak testing methods and applicable lining methods/materials*

Lining Method	Test method in accordance with AS/NZS 2566.2 for non-pressure pipes[(a)]			Comments
	Low pressure air	Hydrostatic	Vacuum	
CIPP	Yes	Yes [(a)]	Yes	• Air tests have passed with pin holes in liner. • Ripples present in the liner at the transition into the pipe from the MH can cause plug seal issues. [(a)] Hydrostatic leakage testing for small diameter sewers installed with air pressure (light cure or steam cure) is generally not practical. This leaves visual inspection and low-pressure air testing as viable alternatives.
Spiral wound	Yes	Yes	Yes	• Delay in testing to allow silicon seal to adequately cure, typically 4-6 hours after lining. • Issues with liner profile shape and getting a sound seal to test against.
Slip line – PVC	Yes	Yes	Yes	
Slip line – PE	Not suitable for PE	High pressure test only suitable for PE		
Fold and form	Yes	Yes	Yes	• Ripples present in the liner at the transition into the pipe from the MH can cause plug seal issues.
Segmental liner – circular profile only	Yes	Yes	Yes	

[(a)] High pressure test for Slip line-PE shall be in accordance with AS/NZS 2566.2 for pressure pipelines

Notes:

- In all cases a CCTV inspection is required post lining, providing visual inspection of the liner and the opportunity to identify defects that require remediation or further testing/inspection. It may however not provide visual evidence of leakage through pinholes and LJR's.
- CCTV Inspections at the end of the defect's liability period, such as is currently specified, would be expected to provide evidence of any leakage occurring which may not have been identified during the initial CCTV inspection and / or leak testing.
- Even with a passed leak test, if the defect shows evidence of leaking at the end of the Defects Liability Period it will be repaired at no cost to Watercare.

6.3 As-builts

As-built drawings and pre & post CCTV inspection in both documents and shapefiles shall be submitted within 2 weeks of final acceptance of said work or as specified in the *Project Specification*. As-built drawings will include all work completed by the Contractor.

6.4 Reinstatement

Following the completion of the sewer rehabilitation works and the return of the sewers to normal operation, all affected areas of the Site shall be reinstated to a condition at least equal to that existing prior to the commencement of work. This includes any decontamination where areas were in contact with wastewater. The records of the pre-condition site survey carried out prior to the commencement of site works shall be used in the event of any discussion regarding the extent of reinstatement.

Sewers, manholes or any other facilities adversely affected by the work shall be reinstated to their pre-existing condition or better.

6.5 Document control

The following documentation shall be recorded and submitted to Watercare as part of Document Control and final acceptance.

- Assessment of the original pipeline detailing the condition of the existing pipeline and selection process of the preferred technique(s).
- Specification developed for the preferred technique(s).
- Installation records including Contractor inspection and testing plans.
- Compliance statements (CS1 and CS3)
- Material data sheets for all materials used in the lining process.
- Sampling and certificates of test results
- Acceptance and testing records including any defects and remediation works completed.
- As-builts detailing the rehabilitation method, materials, pipe or liner diameters and location of any laterals.
- Approved asset creation sheets capturing new assets and attributes (refer to Watercare's *Asset Information and Data standard*).

Appendix A: Checklist

No.	Document	Completed / Document(s) Supplied	Reference Section	Contractor	Watercare Representative
Pre-construction					
1	Complete Watercare's Health and Safety induction	Completed	5.1.2		
2	Control of Work documentation submitted	Access Authorisation (AA) to the existing network, Job Safety Analysis (JSA), relevant work permits.	5.1.2		
3	Work Method Statement (construction management plan)	Submitted and approved	5.1.3		
4	Flow management plan	Submitted and approved	5.1.4		
5	Quality Control Plan	Submitted and approved	5.1.5		
6	Pre-condition survey	Completed	5.1.6		
7	Cleaning and preparation of the pipeline	Landfill docket	5.1.7, 5.1.8 & 5.1.9		
8	CCTV inspection prior to lining	Completed and submitted.	5.1.10		
9	Manhole condition assessment	Completed and submitted.	5.1.11		Confirm decision to rehabilitate manholes
10	Confirmation of pipe sizes and location of lateral connections	Confirmed	5.1.12		
11	Preparation after cleaning	Repairs completed – evidence provided and accepted.	5.1.13		
12	Liner Material	Certificates matches design, WMS, Watercare specification	4		
Installation (Construction of liner)					
13	Install liner, including reinstatement of lateral connections.	Liner installed free from defects.	5.2.1 – 5.2.7		
14	Grouting around liner (if applicable)	Completed and accepted.	5.2.8		
15	End termination and epoxy around manholes.	Completed and accepted.	5.2.9		
Acceptance Control					
16	Complete post installation CCTV inspection	Completed and accepted.	6.1		
17	Leak testing	Completed and accepted.	6.2		
18	As-builts	Completed and accepted	6.3		
19	Reinstatement of site	Completed and accepted.	6.4		
20	Submission and acceptance of handover documentation	Completed and accepted.	6.5		

Appendix B: Example Inspection and Test Plan

Contractor Name	ABC Limited	**To be completed, submitted, and approved before works can commence**	**Complete Watercare's Health and Safety induction**	*Yes*	*Date*
Project Reference	(Project Name)		**Control of Work documentation submitted (AA, JSA, Work Permits etc.)**	*Yes*	*Date*
Contractor Representative			**Work Method Statement**	*Yes*	*Date*
			Flow management plan	*Yes*	*Date*
			Quality Control Plan	*Yes*	*Date*

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Upstream Structure (e.g. MH 01)	**Downstream Structure (e.g. MH 02)**	**Pipe Cleaned (Yes / No)**	**Flow Management in place (Yes/No)**	**CCTV Inspection (Reference Report No.)**	**Confirm Pipe Size (mm)**	**Confirm Liner Size (mm)**	**Liner Material and Certificates**	**Confirm location of laterals**	**Pipeline preparation after cleaning (e.g. repairs)**	**Installed liner - no defects**	**Grouting around liner anulus (if required)**	**Liner termination and epoxy around manholes**	**Post-installation CCTV**	**Testing and sampling of pipeline**	**Remediate all defects**	**Contractor's Representative**
MH01	*MH-02*	*Yes*	*Yes - in place (17/04/2024)*	*Yes: Report No. 1234 (18/04/2024)*	*475mm*	*400 mm*	*PVC-U / Yes*	*Yes*	*Repairs completed (21/04/2024)*	*Yes*	*Not required, only at terminations*	*Yes (25/04/2024)*	*Yes: Report No. 9876 (26/04/2024)*	*Pass – Report No. (30/04/2024)*	*Completed (02/05/2024)*	*Signed and Date*