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5.01 Introduction

The City Sanitary Sewer Master Plan shall be used as a reference in the design of individual sewer networks.

Where future development is serviced by the existing sanitary sewer system, the City will conduct an analysis using the network model at the expense of the Applicant. The analysis will review system flows and velocities for conformance with City specifications and guidelines to identify any upgrades needed as part of the development proposal. Existing facilities which are undersized or inadequate to accept additional sewage must be upgraded at the Applicant's expense to accommodate the flows.

5.02 Sewage Characteristics

5.02.1 Design Flow

The sanitary sewer system shall be designed using the following average daily flows for the zone noted:

Residential/Institutional	300 litres/capita/day
Industrial/Commercial	22,500 litres/day/hectare
Hotel	300 litres/day/patron
Motel	500 litres/day/patron

In the absence of detailed design population information, the following minimum design population densities shall be used.

Areas	Population Density
Single Family Dwelling	2.2 ppu or 28 ppha
Multiple Family Dwellings	1.3 ppu or 37 ppha
Industrial (or equivalent of)	36 ppha
Commercial (or equivalent of)	90 ppha (including parking)
Institutional (or equivalent of)	50 ppha (including park, but not green space)

Peak flow shall be $6.75P^{0.11}$ where P is the population of the contributing area.

For commercial and industrial lands, P shall be the equivalent population determined by dividing the average daily flow by 300 litres per capita per day.

An infiltration rate of 12,500 litres per day per hectare shall be added to the peak flow to obtain the design flow.

5.02.2 Sewage Quality Criteria

a) Sewage quality criteria shall be as follows.

Direct Service Area	Parameters	Normal Average	Maximum Short Duration
Less than 50,000 L/d	BOD (Biological Oxygen Demand) 5 day 20°C.	200 mg/L	300 mg/L
	TSS (Total Suspended Solids)	220 mg/L	350 mg/L
	pH	5.5 to 11.0	3.5 to 11.5
	Fats, Oil & Grease (FOG)	50 mg/L	100 mg/L
	Petroleum Hydrocarbon	5 mg/L	15 mg/L
	Temperature	45°C	<100°C (domestic wastewater) <65°C (industrial wastewater)
Over 50,000 L/d	BOD (Biological Oxygen Demand) 5 day 20°C.	180 mg/L	300 mg/L
	TSS (Total Suspended Solids)	200 mg/L	350 mg/L
	pH	5.5 to 11.0	4.0 to 11.5
	Fats, Oil & Grease (FOG)	50 mg/L	100 mg/L
	Petroleum Hydrocarbon	10 mg/L	15 mg/L
	Temperature	45 °C	<100°C (domestic wastewater) <65°C (industrial wastewater)

*1 Fats, Oil & Grease – does not include petroleum hydrocarbons.

- b) Regulations, including the Regional District of Nanaimo Regional Sewage Source Control Bylaw No. 1730, 2015, that govern wastewater quality acceptable for treatment by the French Creek Sewage Treatment facility shall be adhered to. The more stringent of a) above or b) governs.
- c) For industrial and commercial developments, wastewater sampling and pre-treatment may be required prior to discharge to the City of Parksville sewer system. If the City Engineer requests treatment, monitoring and sampling may be necessary, with all costs related to sampling and reporting at the expense of the property owner.

5.03 Pipe Capacity

The following criteria shall be used when calculating pipe sizes.

Gravity Sewers: Manning's formula shall be used.

$$Q = \frac{AR^{0.667} S^{0.5}}{n}$$

where
Q = design flow in m³/s
A = cross sectional area in m²
R = hydraulic radius (area/wetted perimeter) in metres
S = slope of hydraulic grade line in m/m
n = roughness coefficient
= 0.013 for concrete pipe
= 0.011 for smooth PVC pipe

Gravity sanitary sewers shall be sized for a maximum of 70 percent of full capacity.

Force Mains: Hazen-Williams formula shall be used.

$$Q = \frac{CD^{2.63} S^{0.54}}{278,780}$$

where
Q = rate of flow in L/s
D = internal pipe diameter in metres
S = slope of hydraulic grade line in m/m
C = friction coefficient = 120

5.04 Sanitary Sewer Location/Corridors

Sanitary sewers shall be located within the road right-of-way, as specified on the applicable standard road cross section. (Refer to Section 7.0.)

If the utility crosses private land, the required right-of-way shall be a minimum of 4.0 metres wide. Where both a storm drain and a sanitary sewer are in one right-of-way, the width shall be a minimum 5.6 metres.

If a utility with manholes, valve chambers or other appurtenances that require maintenance are located within a right-of-way, the Applicant shall provide a constructed road access from a City road for maintenance vehicles. The access shall be able to support the maintenance vehicles for which the access is intended.

All sanitary sewer mains shall be installed at a minimum clear horizontal distance of 3.0 metres, and a vertical distance of 0.5 metres from any water main, with the water main on top. If the minimum horizontal clearance cannot be obtained, then the water main shall be protected to the satisfaction of the Regional Public Health Engineer. If a minimum clear vertical separation of 0.5 metre cannot be established, then the water main is to be fully concrete encased or wrapped with petrolatum tape at all joints within 3 metres of either side of the crossover point.

5.05 Minimum Pipe Sizes and Materials

The minimum sanitary main line pipe diameter is 200 millimetres, except for the last upstream section, which may be 150 millimetres, provided the sewer cannot be extended in the future.

The following pipe material is permitted for sanitary sewers:

	Size Range (mm)	Material	Use	Specification
5.06	100 to 150	Polyvinyl Chloride (PVC)	Service Connections	SDR28 minimum, ASTM D3034, and CSA B182.2
	200 to 675	Polyvinyl Chloride (PVC)	Mains and larger service connections	SDR35 minimum, ASTM D3034 OR ASTM F679 and CSA B182.2
	Greater than 675	Reinforced concrete	Mains	ASTM C76M Class II I or higher
	All sizes	High Density Polyethylene	Force Main	SDR21 minimum, AWWA C906
	Other	As approved by the City Engineer		

Community Plan (OCP). The minimum cover requirements, as set out above, may be reduced upon approval by the City Engineer.

The class and type of pipe and fittings, together with required class of bedding and trench widths, shall be such that the pipe will support the anticipated earth and any surface dead and live loads, with a safety factor of 1.5 for rigid and 1.9 for non-rigid pipe.

5.07 Minimum/Maximum Velocity

For gravity mains, the minimum velocity shall be 0.6 metre per second. There is no maximum velocity; however, consideration must be given to scour problems where flows exceed

2.5 metres per second. Anchoring shall be incorporated where the grade(s) of the sewer are 15 percent or greater.

For force mains, the minimum velocity shall be 0.9 metre per second, and the maximum velocity 3.35 m/s. See Section 5.15, below.

5.08 Minimum Grade

The grade of any sewer is governed by the minimum required velocity (0.6 metre per second). However, the last section of a main that will not be extended in the future shall have a minimum grade of 1.0 percent if 150 millimetre diameter pipe is proposed.

5.09 Curvilinear Sanitary Sewers

Horizontal curves may be installed only if deemed necessary and only if permitted by the City Engineer. Horizontal curves will require a constant offset and/or shall be uniform throughout the curve. The design velocity shall exceed 0.91 metre per second and the minimum grade shall be 1.0 percent. Where pipe deflection is permitted, the maximum joint deflection shall be one-half of the pipe manufacturer's recommendations. There shall be no bending of the pipe. Each joint is to be located by survey prior to covering the pipe.

5.10 Manholes

a) Manholes are required at:

- all changes in grade
- all changes in direction
- all terminal sections unless a cleanout is permitted
- every intersecting sanitary sewer main
- all changes in pipe size
- every 120 metres for pipes equal to or less than 375 millimetre diameter
- every 150 metres for pipes between 400 millimetre diameter and 750 millimetre diameter inclusive
- every 180 metres for pipes equal to or greater than 900 millimetres
- the downstream end of horizontal curvilinear sewers

b) Stubs shall be installed in manholes to allow for future extensions. The length of the stubs shall be 0.60 metre maximum from the outside of the manhole. The end shall be securely capped.

c) Sanitary manhole rim elevations in off road areas shall be designed to be:

- above the adjacent storm manhole rim elevation; and
- above the surrounding ground so that infiltration from ponding will not occur.

5.11 Hydraulic Losses Across Manholes

The following criteria shall be used.

- a) Generally, the crown of the downstream pipe shall not be higher than the crown of the upstream pipe.
- b) Minimum drop in invert levels across manholes shall be as follows.
 - i) straight run - no drop required – minimum of 0.5 percent slope required;
 - ii) deflections up to 45° - 15 millimetre drop;
 - iii) deflections 45° to 90° - 30 millimetre drop.
- c) Outside drop manholes shall be provided wherever the drop exceeds 0.6 metres.
- d) Inside ramps will be permitted up to 450 mm from invert to channel bed.
- e) Drops between 450 millimetres and 600 millimetres are not allowed.

5.12 Cleanouts

Temporary cleanouts may be provided at terminal sections of a main, provided that:

- a) the length of sanitary sewer to the downstream manhole does not exceed 45.0 metres;
- b) the depth of the pipe does not exceed 2.0 metres at the terminal point; and
- c) extension of the main is proposed or anticipated.

5.13 Service Connections

New service connections shall:

- a) be installed to all lots fronting the main, so that each lot is provided with a "gravity-flow" connection. Inspection chambers shall be installed at the property line in a concrete service box. All services shall enter the main as depicted on the standard drawings.
- b) be single connections only, unless approved by the City Engineer;
- c) be connected to new mains using wye fittings, and be connected to existing mains using wye saddles;
- d) have a minimum diameter of 100 millimetres;
- e) have a minimum depth of 1.0 metre at the property line;
- f) be permitted into manholes (upon the approval of the City Engineer) provided that:
 - i. the connection is not in an adverse direction to the flow in the sewer main;
 - ii. the provisions noted in Section 5.11 are met;
- g) have a slope of not less than 2.0 percent from the main to the property line.

5.14 Sanitary Pump Stations

The use of sanitary pump stations is discouraged. Any proposed use of pump stations must receive prior approval from the City Engineer. Any sanitary pump station must be located within a right-of-way outside the road dedication.

The size, capacity and type of station will depend on the development and catchment area.

The following criteria apply.

- a) All sanitary pump stations shall be designed with two pumps, each capable of handling the maximum flow, independent of the other.
- b) Each pump must be:
 - capable of passing solids up to 75 millimetres in size
 - equipped with hour meters
 - easily removable for maintenance
 - operational on a 347/600 volt electrical source (Pump motors over 5 horsepower are to be 600 volt phase 3 type.)
 - able to operate alternately and independently of the other pump.
- c) Cables including motor cables and power cables shall be continuous from within the pump station to within the kiosk. In no instance shall a cable be spliced.
- d) Level controls shall be ultrasonic as per City requirements.
- e) All auxiliary equipment and control panels shall be mounted in a suitable kiosk adjacent to the station. The kiosk shall be located a minimum of 3.0 metres from the station lid.
- f) The control kiosk shall be designed to contain all control and SCADA equipment on the front panel and all power equipment on the rear panel.
- g) Check valves shall be weight type.
- h) All stations require an explosion-proof exhaust fan which can be activated by opening the entrance cover and/or by manual switch. The fan must have sufficient capacity to exchange the total volume of air inside the station with fresh air within three minutes of activation.
- i) The entrance to all stations must be waterproof and provided with a suitable lock. The cover may be either aluminum or iron and must have a counterweight to facilitate opening. The entrance should be at ground level where feasible, but in no case should it be more than 300 millimetres above the ground. An explosion-proof light with a

protective cover should be installed in a suitable location in the station. The light should be activated by the entrance cover.

- j) Access into the station shall be by an aluminum ladder. The location of the ladder shall not interfere with the removal and installation of the pump and other appurtenances. The ladder shall be designed to extend and lock at least 600 millimetres above the station entrance. A platform shall be provided above the high water level float to permit wet well access if the total depth from ground level to the wet well floor exceeds 2.40 metres.
- k) All wiring shall be explosion-proof, Class 1, Division 2. Electrical design and installation is subject to the acceptance of the Provincial Safety Inspector. Metal stations shall be protected by at least two 32 pound magnesium anodes.
- l) All stations shall provide an automatic generator for standby power in case of power failure. Provision for a telemetry system must be included for connection into the City's SCADA system.
- m) All equipment must be CSA approved and have at least a one year guarantee for parts and labour. The supplier is to provide three sets of operating and maintenance manuals to the City. All pumps must be factory tested prior to installation.
- n) A gate valve is required on the influent line and on each pump discharge. The valves shall be outside the station and be complete with square operating nuts and nelson boxes.
- o) A water connection for cleaning purposes must be provided. A backflow preventer, per the City's Cross Connection Bylaw, is required for the water connection.
- p) The roof and cover of the pump station should be designed to withstand H2O loading (Highways Standard), with the safety grating part of the lid.
- q) Provision must be made for standby pumping from an external source. An adapter flange ("Kamlock"), complete with a quick coupling and lockable cap will be required.
- r) The control panel must incorporate an extra plug-in, a Crouse Hinds receptacle, and an automatic transfer switch for a standby power source. Underground electrical wiring is required.
- s) The area around the station, including all associated equipment and buildings shall be asphalted. The size of the area is to be determined by the requirements for maintenance.

- t) A receptacle, compatible with the City's removable lifting arm, shall be incorporated into the design of the pump station to facilitate the removal and installation of the pumps.
- u) The interior surfaces of all steel and fibreglass stations shall receive at least two coats of two component white epoxy enamel.
- v) The wet well bottom shall be benched to direct all solids into the pump suction. The influent line shall be located tangent to the wet well to encourage scouring of the wet well.
- w) The pump control panel must incorporate the following indicator lamps:
 - pump on (green), each pump
 - pump fail (red), each pump, manual reset
 - high water level (red), manual resetAll indicator lamps must be "push to test" type.
- x) A meter that records flow at five minute intervals shall be installed in the panel for each pump.
- y) An ampmeter must be provided for each pump, switchable to each phase for three phase systems.
- z) A complete set of spare circuit cards are to be provided where modular card-type pump controllers are used.

5.15 Force Mains

In conjunction with sanitary pump stations, the following criteria shall be used in the design of force mains.

- a) Velocity
A cleansing velocity of at least 0.9 metres per second shall be maintained for the lowest anticipated pump delivery rate that occurs at least once per day. The maximum allowable velocity is 3.5 metres per second.
- b) Air Relief Valve
An automatic air relief valve shall be placed at high points in the force main to prevent air locking.
- c) Termination
Force mains should enter the gravity sewer system at a point not more than 600 millimetres above the flow line of the receiving manhole. An inside drop pipe shall be incorporated.

- d) Size
The minimum allowable diameter for force mains is 100 millimetres.

- e) Materials
The material selected for force mains shall meet the standards in Section 5.05, and be appropriate for site specific conditions, for example, industrial waste, unusual soil characteristics, exceptionally heavy external loading, and abrasion.

All force mains shall be designed to prevent damage from superimposed loads, water hammer and column separation phenomena.

5.16 Scope

These specifications govern the installation of all sanitary sewer pipe and appurtenances within the City.

5.17 General

The flow in all existing sewers and service connections shall be maintained during construction. The contents of any new sewer pipe or service connection shall not be allowed to flow into the trench or into the mains except where permission is given by the City Engineer. All offensive matter capable of contaminating or obstructing sanitary sewers shall immediately be removed from the work area, using such precautions as may be directed by the Works Inspector.

5.18 Excavation

5.18.1 Blasting can proceed only with permission from the City Engineer.

5.18.2 If the sewer is not located under pavement, sidewalk, driveway or gravel shoulder, all topsoil to a maximum depth of 300 millimetres shall be removed and stockpiled for replacement.

5.18.3 The trench shall be excavated to the required alignment, width, depth, and grade as shown on the standard drawing. When trenching along or across a paved surface, pavement shall first be saw cut in straight lines parallel to the trench centerline. The total width of cut pavement shall not be greater than the specified maximum trench width at the ground surface shown on the drawings. Where, in the opinion of the City Engineer, existing pavement is in such poor condition that a saw cut is not warranted, pavement may be cut with trenching equipment.

5.18.4 Where trenches are excavated on the traveled portion of a road, all excavated matter shall be removed from the site except in cases where approval is recommended by the geotechnical engineer and given by the Works Inspector for the use of this material as backfill. The Contractor shall ensure that existing asphalt surfaces are not scarred by track equipment. If damage to the pavement occurs, the Contractor will take full responsibility for the cost of providing a pavement overlay to the satisfaction of the City Engineer.

5.18.5 The clear width of the trench at the top of the pipe shall be no greater than that specified on the standard drawing. Where this is exceeded, the Consultant shall obtain approval of the City Engineer before further construction continues.

- 5.18.6 If, in the opinion of the City Engineer, trench width exceeds the maximum allowable for pipe support, the Contractor shall provide a higher class of bedding, a pipe with a higher strength class or concrete encasement.
- 5.18.7 If the bottom of the trench is organic or other unsuitable material, the trench shall be excavated to firm ground, or other remedial measures shall be taken as required by the Consultant, subject to the approval of the City Engineer.
- 5.18.8 Any excavation carried out below the pipe invert shall be backfilled with appropriate granular pipe bedding. This material shall be compacted with approved mechanical compactors in maximum 150 millimetre lifts. The trench bottom shall be firm and capable of supporting the pipe to be installed.
- 5.18.9 All water, soft silt or disturbed material shall be removed from the bottom of the trench prior to placement of bedding.
- 5.18.10 All solid rock boulders and large stones shall be removed to provide a minimum clearance of 150 millimetres around the pipe. When the end of the service connection is in solid rock, the rock must be blasted 3.0 metres past the end of the connection.
- 5.18.11 Where an existing structure or underground installation may be affected by the works, it is the responsibility of the Consultant to inform the owner of the potential impact of the works in advance of construction so that the owner can specify protective measures for the structure or installation.
- 5.18.12 Where an unforeseen obstruction is encountered that interferes with the designed alignment, the Consultant shall stop construction and not proceed until such time as revised design is approved by the City Engineer.

5.19 Bedding

- 5.19.1 Bedding shall be well graded. Bedding material shall be granular in nature, free of organic material, silt and clay, and shall conform to the following gradation limits when tested in accordance with ASTM C136.

Sieve Designation	Gradation Limits (Percent by Weight Passing)	
	Type 1*	Type 2**
19.0 millimetres	100	90 – 100
12.5 millimetres		65 – 85
9.5 millimetres	85 – 100	50 – 75

Sieve Designation	Gradation Limits (Percent by Weight Passing)	
	Type 1*	Type 2**
4.75 millimetres	70 – 100	25 – 50
2.36 millimetres		10 – 35
1.18 millimetres	20 – 65	
0.850 millimetres		5 – 20
0.600 millimetres	0 – 45	
0.425 millimetre		0 – 15
1.180 millimetres		0 – 8
0.150 millimetre	0 – 10	
0.075 millimetre	0 – 5	0 - 5

- 5. 19.2 Type 1 is the standard bedding type and shall be used for dry trench conditions. Type 2 shall be used for wet trench conditions as determined by the City Engineer or Consultant prior to use. If there is a potential for migration of soils from trench walls, filter fabric may be required.
- 5.19.3 All pipes shall be bedded in accordance with the standard drawing. Bedding material shall be compacted to a minimum 95 percent Modified Proctor Density in compliance with ASTM D1557.
- 5. 19.4 Bedding shall be compacted in equal lifts not exceeding 150 millimetres and under the pipe by means of a hand tamping bar.
- 5. 19.5 Field compaction tests of pipe bedding will be conducted a minimum of once per day. All compaction tests are to be submitted to the Consultant and to the City Engineer for review.
- 5. 19.6 Alternate bedding materials may be proposed for use only where approved by a geotechnical engineer. Alternate material will require approval by the City Engineer (subject to sieve analysis at the cost of the proponent).

5.20 Materials

All pipe shall be free of defects and shall be of the size and class shown on the design drawings.

5.21 Field Support Strength

Details of pipe bedding are shown on the standard drawing.

5.22 Installation

5.22.1 Pipes shall be handled, stored and laid in accordance with the recommendations of the pipe manufacturer. It is unacceptable to pass chains or cables through pipe bore so that the weight of the pipe bears on the pipe ends. Gaskets shall be installed according to manufacturer's specifications on all pipes.

5.22.2 All pipes shall be laid on a prepared bed, true to line and grade. The barrel of each pipe shall be in contact with the shaped bed along its full length. Line and grade shall be established using lasers or other approved methods.

5.22.3 All pipe must be laid to the designed alignment and grade within the following tolerances.

- a) Horizontal tolerance from true line shall not be greater than 60 millimetres from the designated location. The rate of deviation shall not exceed 40 millimetres in 10 metres.
- b) Vertical tolerance from true grade varies with the grades and shall not exceed the limitations as detailed in the table below.

Grade	Maximum departure from design elevation	Maximum rate of deviation
over 5 percent	30 millimetres	6 millimetres in 3 metres
5 percent or less	15 millimetres	3 millimetres in 3 metres

5.22.4 Where a sanitary sewer is being constructed as an extension to an existing City system, the end of the existing pipe shall remain sealed until the sewer extension is completed, flushed, tested and accepted by the City. Upon acceptance, the seal may be removed and one length of pipe installed to connect the extension to the existing system.

5.22.5 All service connections shall be installed as shown on the standard drawings. An inspection chamber must be provided at property line in a concrete box. Service connections shall be installed perpendicular to the main.

5.22.6 Where sanitary sewers and storm drains are installed in a common trench, there shall be a minimum 300 millimetres lateral clearance between the walls of the pipes and trench walls.

5.23 Manhole and Cleanout Construction

- 5.23.1 Standard manholes shall be constructed and benched as shown on the municipal standard drawings.
- 5.23.2 Where approved by the City Engineer, riser manholes will be constructed in accordance with the standard drawing.
- 5.23.3 Cast-in-place manholes will be allowed provided the following criteria are met.
 - a. Concrete attains a minimum strength of 28 megapascals at 28 days;
 - b. Minimum wall thickness is 150 millimetres;
 - c. Minimum internal dimensions are as specified on the standard drawing.
- 5.23.4 Manhole frames shall sit on a minimum of two grade rings that shall be parged on both sides with a mortar paste composed of one part cement and three parts of sand and only sufficient water for workability. The grade separation between the frame and manhole top shall be greater than 100 millimetres and less than 200 millimetres.
- 5.23.5 Heavy duty frames and covers, as per the standard drawing shall be installed on manholes and cleanouts.
- 5.23.6 All sanitary sewer cleanouts shall be constructed as per the standard drawings.
- 5.23.7 Sanitary manholes and cleanouts located in the boulevard shall be set above finished landscaped elevation, or 50 millimetres above grade if the landscaped elevation is not available, so that infiltration into the manhole or cleanout will not occur.

5.24 Service Connections to Existing Mains

Service connections to existing sanitary sewers are to be made by the Contractor unless otherwise directed by the City Engineer. The connections shall be made with the Works Inspector present, to the Engineering Standards and Specifications requirements and to the satisfaction of the City Engineer. Plugs shall be removed from inspection chambers prior to installation.

5.25 Backfill

- 5.25.1 Where a pipe is installed beneath an existing or future pavement, sidewalk, driveway or gravel shoulder, the backfill shall be imported granular fill or equal, compacted to a minimum 95 percent Modified Proctor Density.

Backfill used in untraveled areas such as boulevards and easements shall be compacted to a minimum 90 percent Modified Proctor. Compaction shall be in layers of 150 millimetres using a plate compactor or in 300 millimetre layers using a hydraulic compactor.

5.25.2 If required to meet optimum moisture content, a controlled amount of water shall be added to the gravel for compaction.

5.25.3 Suitable native materials may be used as backfill in road areas provided it has been tested and approved by the geotechnical engineer. Backfill in these cases shall be free of stones over 150 millimetre size, frozen material, and organic or other perishable or objectionable material that would prevent proper consolidation or cause subsequent settlement.

Approved native backfill material shall under no circumstance have a silt and clay content exceeding 30 percent by volume.

5.25.4 Imported granular fill used for backfill shall consist of well graded granular material, with not more than eight percent passing the 0.075 millimetre sieve, which contains no stones larger than 150 millimetres in diameter and contains no stumps, roots, organic or other deleterious material.

5.25.5 Where it is required to replace topsoil it shall occupy the upper 300 millimetres of the trench and shall be heaped and compacted on top to allow for settlement. If the installation is under a lawn, the soil shall be fine raked during the appropriate season and sown with a top quality grass seed at the rate of 50 grams of seed per square metre and rolled. In certain conditions, the City Engineer may request the placement of sod over the trench.

5.25.6 Pavement that has been removed to permit trenching shall be disposed of as waste material and shall not be placed in the trench under any circumstances.

5.25.7 Field compaction tests of trench backfill shall be conducted a minimum of once per day and shall act as a method of quality control for the Contractor. All compaction tests are to be submitted to the Municipal Works Inspector for review.

5.26 Clean Up

5.26.1 The Contractor shall take precautions to prevent debris and mortar droppings from entering any part of the sanitary sewer system and shall leave all pipes, manholes, cleanouts and other appurtenances in a thoroughly clean condition to the satisfaction of the Municipal Works Inspector.

- 5.26.2 The Contractor shall remove excess materials, and clean up the construction area immediately in order to maintain site safety.
- 5.26.3 The Contractor shall restore all disturbed surfaces to a condition equal to or better than the condition that existed prior to construction to the satisfaction of the Municipal Works Inspector.
- 5.26.4 The construction shall not be considered complete until the City Engineer has provided final acceptance of the works.

5.27 Cleaning, Flushing and Testing

5.27.1 Cleaning and Flushing

Upon completion of sanitary sewer pipe installation, the pipe shall be cleaned to the satisfaction of the Municipal Works Inspector by power flushing with water to remove all foreign material from the system. Flushing shall continue at least until flow from the most distant point has reached discharge point and until the discharged water is clean and clear. Silt and debris shall be prevented from entering the downstream system during flushing.

The use of City water for flushing may or may not be permitted depending on water restrictions in effect at the time. The Contractor shall contact the Engineering Department for a "Hydrant Use Permit" prior to using any City hydrant as a water source. When flushing close to environmentally sensitive areas, the use of sodium thiosulfate is required.

5.27.2 Testing Procedures - General

All newly constructed sewers and manholes, including services, shall be air or water tested. All testing shall be witnessed by the Municipal Works Inspector.

After the pipe has been installed and the trench completely backfilled, the Contractor shall test the sewer system for improper jointing, fractures, broken pipes and other defects. Air testing as described in paragraph 5.26.3(a) will be the primary means of testing sewer lines up to and including 750 millimetres in diameter.

Infiltration or exfiltration tests shall be substituted for air testing if required by the City Engineer.

If the sewer being tested fails to pass an acceptance test, the Contractor shall determine the point or points of leakage, repair or replace all defective materials, and make good any defects in workmanship. The repaired or reconstructed section of sewer shall be retested after completion of backfilling.

5.27.3 Exfiltration Test - Gravity Mains

a) Low Pressure Air Test

Manholes shall be tested either by the exfiltration test utilizing water or by a low pressure air test where specific approval of the test procedure has been provided by the City Engineer.

The air test shall be conducted by increasing the pressure in the test section to 24 kilopascals above the average groundwater pressure and observing the rate of pressure drop.

Before the commencement of the test period, the internal air pressure in the test section shall be maintained 25 kilopascals above the average groundwater pressure for at least five minutes. The air pressure must be regulated to prevent the pressure inside the test section from exceeding 35 kilopascals above the average groundwater pressure.

The test period shall commence when the pressure decreases to 24 kilopascals above the average groundwater pressure and shall end when the pressure decreases to 20.5 kilopascals above the average groundwater pressure. During the test period, additional air shall not be added to the test section. If the test period is less than:

- 2 minutes and 32 seconds for 100 millimetre pipe
- 3 minutes and 50 seconds for 150 millimetre pipe
- 5 minutes and 6 seconds for 200 millimetre pipe
- 6 minutes and 22 seconds for 250 millimetre pipe
- 7 minutes and 39 seconds for 300 millimetre pipe
- 8 minutes and 56 seconds for 350 millimetre pipe
- 9 minutes and 35 seconds for 375 millimetre pipe
- 10 minutes and 12 seconds for 400 millimetre pipe
- 11 minutes and 34 seconds for 450 millimetre pipe
- 12 minutes and 45 seconds for 500 millimetre pipe
- 13 minutes and 45 seconds for 525 millimetre pipe

the sewer shall be deemed to have failed the test. The sewer shall be retested upon completion of repairs to any leaks. The City reserves the right to withdraw permission to use this test at any time and to require the Contractor to carry out the exfiltration test utilizing water.

b) Water Exfiltration Test

The exfiltration test shall include testing of the sewer main, service connections and manholes in each section. The test section shall be sealed at its lower and upper ends by means of removable water-tight plugs. The section shall be filled with water to a minimum height of 1.2 metres above the crown of the pipe at the highest point in the section, or 1.2 metres above the elevation of the groundwater, whichever is the higher. All air is to be allowed to escape from inspection chambers that have been plugged during the filling with water.

Pressures in excess of three metres of water head are not recommended. Damage resulting to the section being tested as a result of testing shall be repaired by the Contractor. The test pressure shall be maintained for a minimum of three hours and, unless excess exfiltration requires further testing, a maximum of eight hours.

The allowable leakage from the pipe shall be calculated by using the following formula.

$$\text{Allowable Leakage (litres)} = \frac{H \times D \times L}{840}$$

Where H = Duration of test in hours
D = Inside pipe diameter (millimetres)
L = Length of pipe test section (metres)

The above exfiltration limit shall constitute the maximum total allowable exfiltration from sewer mains, service wyes, services, manholes and appurtenances along the test sections of pipe.

If a test section has an exfiltration amount in excess of the allowable, the Contractor shall replace or repair the section of sewer. Such sections shall be retested until they meet the allowable leakage limit.

All manholes that have failed the exfiltration test shall be tested for water-tightness by filling the structure with water to two metres above the invert of the pipe (or 100 millimetres below ground level, if the pipe invert is less than two metres below grade). No measurable drop in one hour will constitute an acceptance test.

5.27.4 Hydrostatic Test - Force Mains

Testing procedures must be forwarded to and approved by the City Engineer. The Contractor shall conduct the following test on force mains.

a) Flushing and Preliminary Testing

The Contractor, while constructing the force main, shall conduct interim tests to ensure that the line is ready for the final pressure test. The Contractor shall ensure that the main is clear of dirt and other foreign materials. The main shall be flushed at water velocities as high as can be obtained from the available water source.

Flushing water shall be discharged to storm sewers or ditches that have sufficient capacity for the excess flow. Flushing shall continue at least until the flow from the most distant point has reached the discharge point and until the water discharged is clean and clear.

b) Testing Procedure

After flushing, the main shall be subjected to a hydrostatic pressure test. The test pressure for sanitary sewers is 1.5 times the operating pressure or 690 kilopascals, whichever is greater. The length of any test section shall not exceed 300 metres.

Immediately prior to testing any section, all appurtenances shall be checked to ensure that they are prepared for the test. Air valves shall be opened while the mains are filled. If all the air from the test section cannot be expelled from existing fittings and appurtenances, the Contractor shall tap the section in an acceptable manner to expel the air.

The main shall then be filled with water and brought to a pressure of 10 percent of test pressure at the testing point. Any air valves in the test section shall then be closed so that test pressures will not cause damage. The main shall remain at the above pressure for a period of at least 24 hours before applying the test pressure.

The pipeline shall then be brought up to the test pressure, which shall be maintained for a period of not less than one hour. Accurate means shall be provided by the Contractor for measuring the quantity of water that is required to maintain full pressure for the test period.

During the 60 minute test, the pressure shall be maintained within 69 kilopascals of the designated test pressure. Pressure piping and appurtenances in such assemblies as pump stations and valve chambers shall be subjected to the same pressure testing procedures as the main lines.

No pipe installation will be accepted until the leakage is less than the number of litres as determined by the following formula.

$$L = \frac{H \times N \times D \times \text{square root of } P}{130,000}$$

- Where L = the allowable leakage in litres
H = the test duration in hours
N = the number of joints in the test section
D = the nominal pipe diameter in millimetres
P = average test pressure during the leakage test in kilopascals

5.27.5 Video Inspection Test

All pipe video inspection including methods of cleaning, equipment and rates of camera travel shall be in accordance with the UK Water Research Centres (WRc), Sewerage Rehabilitation Manual, most current Edition.

A camera video of the sanitary sewer system is required for all gravity sewer mainlines and service connections, in accordance with WRC (Water Research Council) procedures. The inspection shall be recorded on a DVD complete with a printed WRC format report and key plan. Prior to paving, the video inspection shall be completed and reviewed by the Consultant to ensure the pipe is true to grade and clear of debris, and has been installed in accordance with the City of Parksville Engineering Standards and Specifications. Any deficiency that is found during this test shall be promptly remedied by the Applicant at his expense.

Following the review, the Consultant will forward the final video record with a certified report to the City, confirming that the pipe installation meets the City of Parksville Engineering Standards and Specifications. DVD's and records will become the property of the City of Parksville upon submission. The Consultant must retain copies for their own records.

The Applicant shall video re-inspect one month prior to the end of the one year maintenance period. The Consultant shall review this video and make a written recommendation to accept or reject the works based on the results of the video.