TABLE OF CONTENTS

SECTION 3.5 - WATER MAINS

3.5.1 SCOPE

The work described in this section pertains to the installation of water main piping, appurtenances, and connections to existing water mains.

3.5.2 MATERIALS

All materials used are to be of the manufacture stated on the plans and the specifications described in Section 2.

All work described in this section is to be carried out in strict accordance with manufacturer's recommendations unless otherwise noted.

3.5.2.1 BEDDING SAND

The bedding sand is to be free from organic material and is to meet the following grading requirements:

SIEVE SIZE (mm)	PASSING BY MASS (%)
10.000	100
5.000	80-100
2.000	55-100
0.630	25-65
0.250	10-40
0.080	2-15

The liquid limit is not to exceed 25 and the plasticity index is not to exceed 6.

3.5.2.2 BEDDING STONE

Bedding stone is to be used when wet trenching conditions exist.
The bedding stone is to be free from organic material and is to meet the following grading requirements:

SIEVE SIZE (mm)	PASSING BY MASS (%)
25.000	100
20.000	70-100
12.500	55-100
10.000	30-80
5.000	0 -40
2.000	0-10

3.5.2.3 WATER MAINS AND FITTINGS

Pipe for the water main is to conform to the standards in Section 2.3.2 Water main Pipe Materials.

3.5.2.4 INSULATION

Water mains, if insulated, are to be insulated using a factory-applied, rigid foam material specified in Section 2.3.4

The pipe is to be located at the center of the insulation material. An allowable tolerance on this specification is as follows:

- Total diameter of insulation pipe structure is in no instance to be less than the pipe diameter plus 100 mm.
- The minimum thickness of insulation at any location of the pipe is to be 50 mm.

The Developer is to provide suitable tape and is to tape-wrap all locations where such tests are performed. Materials, which do not comply with the foregoing specification, will be rejected.

The Engineer is to reserve the right to have a representative present at the insulation applicator's plant during insulation application. The Developer is to provide a schedule to the Engineer indicating when the insulation application will take place.

The pipe joints and fittings are to be insulated with a minimum 50 mm polyethylene half shell or where necessary use approved field insulation kits. Protect insulation with polyethylene heat-shrink sleeve or a triple overlapping wrap of suitable heat-shrinking tape.

3.5.2.5 STYROFOAM BOARD INSULATION

Styrofoam board insulation is to be as shown on the construction drawings. Insulation is to be extruded polystyrene with a minimum compressive strength of 35 psi or better. Install using interlocking pieces or overlap sheets 50 mm.

3.5.2.6 HYDRANTS, VALVES AND VALVE BOXES

In-line hydrants are to conform to Section 2.3.5 Hydrants.

Gate valves are to conform to Section 2.3.6.1 Gate Valves.

The Developer is to supply approved gate valves of the size and quantity specified on the construction drawings. Valves are to be installed in accordance with the standard drawings in Section 4.

Valve boxes are to conform to Section 2.3.6.3 Valves Boxes.

Valves on the distribution mains are to be installed as noted in Section 2.3.6.4 Valve Location.

3.5.2.7 CONCRETE

All concrete for pipe cradles and thrust blocking, as well as concrete backing around pipes, buttresses and anchors, where required for the construction of water mains, are to develop a compressive strength of not less than 25 MPa in 28 days. The maximum slump is to be 100 mm. Cement is to be Type 10, normal or Type 50, sulphate resistant as specified by a Geotechnical Engineer. Aggregates, proportioning, measurement, mixing, placing, and finishing is to be in accordance with the applicable sections of CSA Standard CAN3-A.23.1. Concrete poured during temperatures lower than 5 degrees Celsius is to have a temperature not less than 5 degrees Celsius, and suitable means is to be provided to maintain this temperature for 72 hours. Concrete surfaces are to be moist-cured for not less than 24 hours.

3.5.3 INSTALLATION

3.5.3.1 LAYING

The pipe is to be laid true to the line, grade and depth as per Section 3.4, Trenching and Backfilling, and staked as specified by the Consultant to prevent sags and humps and provide the proper bury at hydrants and valves. Where minor deflections in line or grade are required, the deflections are not to exceed one half the maximum recommended by the pipe manufacturer. Pipe having bell ends is to be laid with the bell ends facing the direction of laying. Pipe is not to be laid in water or in unsuitable trench conditions. To enable proper joints to be made, bell or coupling holes are to be provided in the bedding material. Ends of pipe are to be covered to prevent intrusion of deleterious materials.

3.5.3.2 JOINTS

Pipe joints for high-density polyethylene pipe, ductile iron, and polyvinyl chloride pipe are to be as follows:

Polyethylene Pipe (Butt-fusion)

Wherever possible the polyethylene pipe should be joined by the method of thermal butt-fusion, as outlined in ASTM-D2657, Heat Joining Polyethylene Pipe, and Fittings. Butt-fusion joining of pipe and fittings are to be performed in accordance with procedures recommended by the manufacturer. The high-density polyethylene pipe may be adapted to fittings or other systems by means of an assembly consisting of a polyethylene stub-end, butt fused to the pipe and a backup flange of ductile iron, made to Class 150, ANSI B16.5.

Ductile Iron, Polyvinyl Chloride (Bell & Spigot)

The bell, spigot, and rubber gasket is to be wiped clean and dry immediately before assembly. The joint is to be lubricated and assembled in accordance with the recommendations of the manufacturer. The ring is to be inserted into the groove with the bell collar marking facing outward, in such a manner that it is seated evenly without twists. The ring is not to be lubricated. The spigot is to be lubricated with a film of approved soap lubricant, ensuring that the entire circumference is coated.

It is to then be inserted into the bell and pushed in until the reference mark on the spigot is flush with the end of the bell. All joints are to be made in accordance with AWWA Specification C111. Pipe

deflection at the joints, either vertically or horizontally, are not to be in excess of one half that recommended by the manufacturer.

3.5.3.3 BEDDING AND INITIAL BACKFILL

All water pipes are to be bedded on a 150 mm layer of granular material in accordance with Section 3.5.2, which are to be continued up to the spring line of the pipe and for the full width of the trench. Following bedding, the initial backfill consisting of approved bedding material is to be placed in 150 mm layers from the spring line to 300 mm above the crown of the pipe for the full width of the trench. Bedding and initial backfill is to be compacted to 95% Standard Proctor Density at optimum moisture content. Where a previously installed sewer or other utility is being crossed, the Developer is to install a crossing as indicated in the Standard Drawings, Section 4.

3.5.3.4 APPURTENANCES

3.5.3.4.1 Valves

The Developer, without approval of the Engineer and the utility concerned, is to operate no valve, switch, or other control on existing utility systems for any purpose.

The Developer is to install all valves, fittings, hydrants, air release manholes, flushouts, and other appurtenances at the locations shown on the construction drawings or as directed by the Consultant. Installation is to be in accordance with the standard drawing in Section 4. Appurtenances, which have movable parts, are to be thoroughly examined and operated by the Developer, who is to satisfy themselves before installation that they operate properly and are without visible defects.

Gate valves are to be installed at the locations shown on the construction drawings or as directed by the Engineer, in accordance with the standard drawings in Section 4. Every valve is to be provided with an adjustable valve box. The valve box is to be plumb and centered over the wrench nut of the valve, set evenly on the valve bonnet, be supported so that it does not transmit shock or stress to the valve, and be braced against lateral movement to the sides of the trench. The top of the valve box is to be adjusted to the final elevation required by the Consultant. Valve boxes, which are not plumb or centered over the valve nut, are to be dug up and reset properly at the Developer's expense.

The casing is to be of sufficient length to accommodate the specified cover over the water main. All hydrant valves and tees are to be flanged. The casing is to consist of a hood, one or more intermediate sections, and a top section with a lid. The top section is to be flanged at its lower end and provided with a socket at the ground surface to receive a suitable cast iron lid.

An operating stem of sufficient length to reach within 300 mm of the final elevation of the top of the casing, when casing and operating stem are assembled in place, is to be provided with each valve. The operating stem is to consist of a rod of mild steel having a minimum cross-sectional dimension of 25 mm and a bottom socket or bell of cast iron to fit a standard 50 mm x 50 mm valve operating nut complete with a rock guard.

3.5.3.4.2 Hydrants

Hydrants are to be installed at the locations and elevations shown on the drawings and in accordance with the standard drawings in Section 4. All hydrants are to be plumb with the steamer port perpendicular to the curb line and facing the street.

Hydrants are to have a 300 mm extension at the top as shown on the standard drawings in Section 4. Hydrants that have two nozzles that are 90 degrees apart are to be set with each nozzle facing the street at an angle of 45 degrees.

In-line hydrants are to be connected to the water main by a tee, and a concrete pad is to be installed below the tee. Unless otherwise instructed in these specifications or directed by the Engineer, hydrant drains are to be plugged.

3.5.3.5 REACTIVE BLOCKING

All plugs, caps, tees, crosses, reducers, hydrants, and bends deflecting 11¼ degrees or more are to be anchored to prevent movement. Suitable reaction blocking, as shown on the Standard Drawings, Section 4 or the construction drawings, or as directed by the Consultant, is to be used for this purpose.

Blocking is to be placed between solid ground and the fitting to be anchored. The area of bearing on the pipe and on the ground in each instance is to be in accordance with the drawings or as determined by the Consultant. The blocking is to be placed to ensure the pipe and fitting joints will be accessible for repair. In the case of insulated pipe, the insulation should be removed from the bearing area of the fitting to ensure a direct connection between the pipe and the concrete.

3.5.3.6 CONNECTION TO EXISTING MAINS

The Developer is to make all necessary connections to existing water mains, unless otherwise directed, and is to interrupt service to the existing system for only a minimum period. Prior to making such connections, the Developer is to make all necessary arrangements with the Engineer and is to notify those persons affected by the interruption of the duration of interruption to the service at least 48 hours in advance. All connections are to be made in accordance with the drawings and the specifications. The Engineer is to recover all coupons in a hot tap for inspection.

3.5.4 TESTING

Before acceptance of the work, the entire system is to be subjected to a hydrostatic pressure and leakage test in the presence of the Consultant, according to AWWA standard C600. The Developer is to provide all necessary labour, materials and equipment for the test, including a suitable pump, measuring tank, pressure hoses, connections, plugs, caps, gauges and all other apparatus necessary for filling the main, pumping to the required test pressure and recording the pressure and leakage losses. The Developer is to provide evidence that gauges used are accurate.

The system is to be filled with water slowly and air-bled at each hydrant. If there are sections that cannot be bled from hydrants, due to the profile of the main, the Developer may be required to tap the main at high

points and install temporary bleeder valves. At the completion of testing, these taps are to be satisfactorily plugged at the Developer's expense.

When the line has been filled and most of the air expelled, 24 hours must be allowed for the remaining air and water to reach a constant temperature. The test section may be pressured through a hydrant, or a tap may be installed in the line.

3.5.4.1 PRESSURE AND LEAKAGE TEST

The ductile iron and polyvinyl chloride water main or sections of such water main are to be subject to a pressure of 1.5 times the rated working pressure, or not less than 1035 KPa for a duration of not less than 2 hours. Polyethylene mains are to be subject to a pressure of 1.5 times greater than the rated pressure of the pipe at the lowest elevation of the system, or as specified by the Consultant. Test sections are to extend from hydrant to hydrant. Any exposed pipe, fittings, valves, hydrants, and joints are to be examined carefully during the test. Any damaged or defective pipe fittings, valves or hydrants that are discovered following the pressure test are to be repaired or replaced with sound material, and the test is to be repeated until it is satisfactory to the Engineer.

Tests are to be made only after completion of services, partial or complete backfill, and a minimum of 24 hours after the pipe has been filled with water to allow for absorption into the mortar lining. No test is to be applied until at least 36 hours after the last concrete reaction or thrust block has been cast with high early strength cement. The duration of each test is to be 2 hours. The test section is not to exceed 450m of water main. The allowable leakage is to be determined as follows:

Ductile Iron & Polyvinyl Chloride Pipe Leakage Allowance
Allowable Leakage (litres per 300 m per hour)

Pressure (KPa)	Pipe Diameter (mm)									
	100	150	200	250	300	350	400	450	500	600
3100	2.42	3.60	4.81	6.02	7.23	8.44	9.65	10.82	12.04	14.46
2760	2.27	3.41	4.54	5.68	6.81	7.95	9.08	10.22	11.36	13.63
2410	2.12	3.18	4.24	5.30	6.40	7.46	8.52	9.58	10.64	12.76
2070	1.97	2.95	3.94	4.92	5.90	6.89	7.91	8.68	9.84	11.81
1900	1.89	2.84	3.79	4.69	5.64	6.59	7.53	8.48	9.42	11.32
1720	1.78	2.69	3.60	4.50	5.37	6.28	7.19	8.10	8.97	10.79
1550	1.70	2.57	3.41	4.28	5.11	5.98	6.81	7.68	8.52	10.22
1380	1.63	2.42	3.22	4.01	4.84	5.60	6.43	7.23	8.02	9.65
1210	1.51	2.23	3.03	3.75	4.50	5.26	6.02	6.78	7.49	9.01
1030	1.40	2.08	2.80	3.48	4.16	4.88	5.56	6.28	6.96	8.36

860	1.29	1.89	2.54	3.18	3.82	4.47	5.07	5.72	6.36	7.61
690	1.14	1.70	2.27	2.84	3.41	3.97	4.54	5.11	5.68	6.81

When, in the opinion of the Engineer, there may be possible damage to a newly constructed water main, no pressure and leakage test is to take place between October 15th and April 15th.

3.5.4.2 EXPANSION ALLOWANCE (polyethylene)

The pressure test involves pressurizing the pipe and adding makeup water until the pipe has reached its initial deformation. This level of deformation is usually attained after 3 to 4 hours depending on the size of the pipe. It is characterized by a noticeable reduction in the amount of makeup water required to return the piping system to the test pressure. It is at this time that the actual test period begins. Its duration is to be 2 hours. At the end of the test period, a measured amount of makeup water is to be added to return the pipe to the test pressure. The allowable amount of makeup water is to be determined as follows:

ALLOWANCE FOR EXPANSION UNDER TEST PRESSURE

[LITRES PER 30 M OF PIPE] AT 23°C

Nominal Pipe Size (mm)	1 hour Test	2 hour Test	3 hour Test
75	0.38	0.57	0.95
100	0.49	0.95	1.52
150	1.14	2.28	3.41
200	2.65	4.93	7.96
275	3.79	7.58	11.75
300	4.17	8.72	12.89
350	5.30	10.23	15.92
400	8.33	12.51	18.93
450	8.33	16.29	24.63
500	10.23	20.84	30.31
550	13.26	26.52	39.78
600	17.05	33.72	50.39

700	20.84	42.06	63.27
800	26.52	54.18	85.24
900	34.10	68.19	102.29
1000	41.67	83.35	125.02

The amount of expansion taking place during the pressure testing of polyethylene pipe is dependent on the temperature of the pipe during testing. The temperature of the pipe can be taken as an average of the temperature of the water pumped into the pipe and the temperature of the empty pipe immediately before testing (ambient air temperature). When testing the pipe at temperatures below 23 degrees Celsius, the amount of makeup water should be multiplied by the manufacturer's appropriate correction factor.

3.5.4.3 VALVE TEST

Each section between valves is to be brought to test pressure. Test pressure is to be held without loss for 2 minutes before opening the valve and releasing the pressure into the next section.

3.5.4.4 EXISTING MAINS

Where connections are made to existing water mains, the Consultant is to specify the pressure used to test sections of new water mains that cannot be isolated from the existing water mains, or the Engineer may waive the leakage test. This does not relieve the Developer from his obligation to repair leaks or replace defective material.

3.5.5 DISINFECTION AND FLUSHING

The Developer is to flush the water main with a minimum flow of 0.8 meters per second of water to ensure all foreign materials and contaminants are removed from the line. This practice is to be completed before disinfecting the water main. The table below summarizes the flow conditions required to achieve the specified 0.8 meters per second flow rate:

PIPE DIAMETER (mm)	REQUIRED FLOW FOR 0.8 M/S VELOCITY (L/S)	SIZE OF TAP (MM) NUMBER OF TAPS 25	40	50	NUMBER OF 2.5" HYDRANT NOZZLES*
100	6.5	1	-	-	1
150	13.0	-	1	-	1
200	26.0	-	2	1	1
250	38.0	-	3	2	1

300	57.0	-	-	2	2
450	100.0	-	-	4	2

* With 280 KPa residual pressure, a hydrant flowing to atmosphere will discharge 63 L/s from a 63 mm nozzle and 158 L/s from a 113 mm steamer nozzle.

Assume a 276 KPa residual main pressure.

Before being put into service, and before certification of completion by the Consultant, all installed mains are to be disinfected according to the AWWA Standard C-651 and tested for bacterial content and residual chlorine. After 12 hours, the chlorine residual is to be 20 ppm. Installed mains are to be flushed after passing the chlorine residual test. De-chlorination of super-chlorinated water must be done at time of discharge. Contractor is to submit a complete flushing program for review and approval by the engineer. The Engineer's review does not relieve the Contractor of the responsibility for meeting the requirements of the AWWA Standards and the regulations of Yukon Government and the City of Whitehorse.

3.5.6 MAINTENANCE

If leaks develop in the work before the expiry of the maintenance period, the Developer is to make the necessary repairs. The leaks are to be deemed repaired when the leakage is less than that allowed in sub-section 3.5.4.1 for leakage test.

3.5.7 DAMAGES

Water introduced into the water mains by the Developer is to be at the Developer's risk. The Developer is to repair all damages to the pipe from freezing or other causes.