Supplementary Material

The supplementary material contains three examples of input data and the final design of 3 networks. The first network is Chicó Sur is a network of 109 pipes with variable topography and variable inflow to the manholes, the second example is Chicó Sur flat which again has 109 pipes and the topography is flat and finally the Moeini & Afshar network in this network the length of the pipes is 100m and the inflows to the manholes is 0.00648m3/s, all the complete designs presented in the paper are available by contacting the authors.

1. **Chicó Sur C1 Network**
   1. Input data

Table 1 presents the input data required to design the Chicó Sur C1 network. These data include the inflow, ground elevation and x, y coordinates at each manhole.

Table 1. Input data of the Chicó Sur C1 network.

| **Manholes** | **Coordinate X (m)** | **Coordinate Y (m)** | **Ground elevation (m)** | **Inflow (m³/s)** |
| --- | --- | --- | --- | --- |
| 1 | 2145.39 | 7352.39 | 2561.93 | 0.012 |
| 2 | 1982.51 | 7441.01 | 2558.9 | 0.022 |
| 3 | 1784.49 | 7532.93 | 2557.41 | 0.022 |
| 4 | 1632.28 | 7617.99 | 2557.42 | 0.021 |
| 5 | 1452.89 | 7704.76 | 2555.87 | 0.016 |
| 6 | 1317.86 | 7779.49 | 2554.95 | 0.012 |
| 7 | 2233.12 | 7204.6 | 2568.56 | 0.011 |
| 8 | 2097.16 | 7271.09 | 2563.11 | 0.015 |
| 9 | 1932.99 | 7372.47 | 2557.93 | 0.013 |
| 10 | 1835.94 | 7416.57 | 2557.33 | 0.013 |
| 11 | 1747.32 | 7462.52 | 2556.9 | 0.018 |
| 12 | 1650.5 | 7499.21 | 2556.72 | 0.014 |
| 13 | 1588 | 7531.5 | 2556.62 | 0.017 |
| 14 | 1524.17 | 7564.57 | 2555.87 | 0.013 |
| 15 | 1460.84 | 7597.47 | 2555.78 | 0.013 |
| 16 | 1397.46 | 7630.55 | 2555.37 | 0.013 |
| 17 | 1333.26 | 7661.29 | 2554.93 | 0.009 |
| 18 | 1202.87 | 7770.98 | 2553.85 | 0.009 |
| 19 | 2204.2 | 7149.6 | 2570.03 | 0.011 |
| 20 | 2065.54 | 7218.98 | 2564.85 | 0.02 |
| 21 | 1996.74 | 7259.19 | 2559.69 | 0.01 |
| 22 | 1880.41 | 7313.67 | 2558.7 | 0.019 |
| 23 | 1803.79 | 7353.82 | 2557.34 | 0.013 |
| 24 | 1715.03 | 7400.08 | 2557 | 0.013 |
| 25 | 1144.17 | 7710.55 | 2554.38 | 0.009 |
| 26 | 2157.49 | 7087.17 | 2573 | 0.012 |
| 27 | 2093.6 | 7119.76 | 2568.05 | 0.016 |
| 28 | 2029.41 | 7153.1 | 2565.71 | 0.02 |
| 29 | 1963.14 | 7187.67 | 2562.88 | 0.013 |
| 30 | 1905.84 | 7224.42 | 2560.93 | 0.004 |
| 31 | 1831.54 | 7256.25 | 2559.41 | 0.021 |
| 32 | 1765.15 | 7289.85 | 2557.9 | 0.013 |
| 33 | 1681.29 | 7333.85 | 2557.17 | 0.013 |
| 34 | 1600.04 | 7388.1 | 2557.14 | 0.009 |
| 35 | 1544.46 | 7448.03 | 2556.11 | 0.014 |
| 36 | 1481.47 | 7481.98 | 2555.69 | 0.014 |
| 37 | 1419.46 | 7517.89 | 2555.84 | 0.009 |
| 38 | 1356.12 | 7550.7 | 2555.25 | 0.009 |
| 39 | 1279.69 | 7558.36 | 2554.69 | 0.013 |
| 40 | 1197.64 | 7600.63 | 2554.59 | 0.012 |
| 41 | 1114.68 | 7643.68 | 2554.29 | 0.013 |
| 42 | 1917.32 | 7098.98 | 2564.33 | 0.009 |
| 43 | 1735.7 | 7224.2 | 2558.97 | 0.013 |
| 44 | 1645.68 | 7265.07 | 2557.4 | 0.013 |
| 45 | 1548.16 | 7315.99 | 2556.96 | 0.013 |
| 46 | 1491.4 | 7345.58 | 2556.45 | 0.018 |
| 47 | 1427.55 | 7377.92 | 2555.93 | 0.018 |
| 48 | 1364.27 | 7411.31 | 2555.47 | 0.018 |
| 49 | 1300.92 | 7444.2 | 2554.96 | 0.018 |
| 50 | 1237.38 | 7477.06 | 2554.76 | 0.017 |
| 51 | 1155.71 | 7519.68 | 2554.23 | 0.017 |
| 52 | 1072.14 | 7561.27 | 2553.85 | 0.02 |
| 53 | 1004.44 | 7596.19 | 2553.74 | 0.008 |
| 54 | 2090.9 | 6933.35 | 2575.89 | 0.012 |
| 55 | 2013.31 | 6965.14 | 2569.71 | 0.012 |
| 56 | 1954.28 | 7002.5 | 2566.98 | 0.016 |
| 57 | 1882.86 | 7032.93 | 2565.49 | 0.017 |
| 58 | 1826.73 | 7064.1 | 2564.63 | 0.008 |
| 59 | 1746.82 | 7099.01 | 2562.24 | 0.016 |
| 60 | 1686.22 | 7129.44 | 2560.5 | 0.018 |
| 61 | 1599.01 | 7175.99 | 2558.14 | 0.013 |
| 62 | 1508.1 | 7223.4 | 2557.7 | 0.013 |
| 63 | 1456.74 | 7260.95 | 2557.01 | 0.013 |
| 64 | 1381.43 | 7289.2 | 2556.29 | 0.013 |
| 65 | 1318.17 | 7322.35 | 2555.57 | 0.013 |
| 66 | 1254.73 | 7355.18 | 2555.04 | 0.013 |
| 67 | 1191.38 | 7388.1 | 2554.88 | 0.013 |
| 68 | 1109.34 | 7429.94 | 2554.65 | 0.009 |
| 69 | 962.53 | 7514.74 | 2553.56 | 0.008 |
| 70 | 2056.96 | 6866.81 | 2576.09 | 0.009 |
| 71 | 2002.76 | 6889.27 | 2570.15 | 0.017 |
| 72 | 1920.35 | 6933.78 | 2567.7 | 0.013 |
| 73 | 1832.9 | 6975.88 | 2565.94 | 0.018 |
| 74 | 1728.08 | 7031.72 | 2563.69 | 0.009 |
| 75 | 1649.08 | 7068.52 | 2561.04 | 0.016 |
| 76 | 1559.39 | 7112.63 | 2559.04 | 0.017 |
| 77 | 1471.37 | 7158.01 | 2557.99 | 0.017 |
| 78 | 1393.92 | 7198.28 | 2557.27 | 0.008 |
| 79 | 1305.24 | 7244.35 | 2555.82 | 0.013 |
| 80 | 1230.89 | 7282.92 | 2555.43 | 0.009 |
| 81 | 1155.26 | 7322.23 | 2555.31 | 0.017 |
| 82 | 1076.77 | 7368.03 | 2554.96 | 0.016 |
| 83 | 992.3 | 7407.29 | 2554.09 | 0.02 |
| 84 | 913.3 | 7446.36 | 2554.13 | 0.013 |
| 85 | 826.81 | 7493.27 | 2553.36 | 0.009 |
| 86 | 1958.45 | 6815.65 | 2573.03 | 0.017 |
| 87 | 1785.75 | 6898.33 | 2566.15 | 0.026 |
| 88 | 1604.82 | 6992.61 | 2561.96 | 0.017 |
| 89 | 1530.58 | 7035.67 | 2559.86 | 0.009 |
| 90 | 1434.47 | 7086.98 | 2558.71 | 0.017 |
| 91 | 1268.27 | 7173.47 | 2556.42 | 0.025 |
| 92 | 1116 | 7247.09 | 2555.27 | 0.016 |
| 93 | 1035.11 | 7288.28 | 2554.51 | 0.008 |
| 94 | 955.69 | 7336.9 | 2553.91 | 0.017 |
| 95 | 788.2 | 7419.13 | 2553.05 | 0.017 |
| 96 | 1910.25 | 6726.98 | 2575.18 | 0.013 |
| 97 | 1744.42 | 6812.62 | 2569.26 | 0.021 |
| 98 | 1569.16 | 6903.75 | 2564.49 | 0.018 |
| 99 | 1475.04 | 6952.68 | 2560.78 | 0.013 |
| 100 | 1391.34 | 6997.48 | 2560 | 0.013 |
| 101 | 1302.31 | 7041.85 | 2558 | 0.008 |
| 102 | 1224.8 | 7082.59 | 2555.33 | 0.016 |
| 103 | 1071.64 | 7162.13 | 2554.81 | 0.016 |
| 104 | 981.54 | 7207.82 | 2554.23 | 0.013 |
| 105 | 901.3 | 7249.35 | 2552.05 | 0.013 |
| 106 | 831.25 | 7286.18 | 2551.72 | 0.009 |
| 107 | 741.36 | 7334.18 | 2551.63 | 0.013 |
| 108 | 667.44 | 7367.24 | 2551.46 | 0.017 |
| 109 | 584.86 | 7408.61 | 2555.5 | - |

* 1. Final design

Table 2. Design of the Chicó Sur C1 network.

| **ID Pipe** | **Upstream manhole** | **Downstream manhole** | **Upstream invert elevation (m)** | **Downstream invert elevation (m)** | **Length** | **Diameter (m)** | **Slope (-)** | **Type Pipe** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 83 | 84 | 2552.89 | 2552.53 | 88.13 | 0.2 | 0.0041 | Outer |
| 2 | 19 | 7 | 2568.83 | 2567.36 | 62.16 | 0.2 | 0.0237 | Outer |
| 3 | 84 | 85 | 2552.53 | 2551.96 | 98.39 | 0.2 | 0.0058 | Inner |
| 4 | 76 | 61 | 2557.64 | 2556.44 | 74.74 | 0.4 | 0.0161 | Inner |
| 5 | 91 | 79 | 2555.22 | 2554.42 | 79.95 | 0.2 | 0.0100 | Outer |
| 6 | 59 | 31 | 2561.04 | 2558.21 | 178.63 | 0.2 | 0.0158 | Outer |
| 7 | 19 | 20 | 2568.83 | 2563.65 | 155.14 | 0.2 | 0.0334 | Outer |
| 8 | 58 | 59 | 2563.43 | 2561.04 | 87.24 | 0.2 | 0.0274 | Inner |
| 9 | 86 | 71 | 2571.83 | 2568.95 | 85.97 | 0.2 | 0.0335 | Outer |
| 10 | 98 | 99 | 2563.29 | 2559.58 | 106.14 | 0.2 | 0.0350 | Inner |
| 11 | 24 | 11 | 2555.2 | 2555 | 70.30 | 0.8 | 0.0028 | Inner |
| 12 | 87 | 88 | 2564.95 | 2560.66 | 204.07 | 0.3 | 0.0210 | Inner |
| 13 | 75 | 76 | 2559.64 | 2557.64 | 99.97 | 0.35 | 0.0200 | Inner |
| 14 | 22 | 9 | 2557.5 | 2556.73 | 78.88 | 0.2 | 0.0098 | Outer |
| 15 | 73 | 74 | 2564.54 | 2562.39 | 118.79 | 0.25 | 0.0181 | Inner |
| 16 | 90 | 91 | 2557.51 | 2555.22 | 187.37 | 0.2 | 0.0122 | Inner |
| 17 | 26 | 27 | 2571.8 | 2566.85 | 71.89 | 0.2 | 0.0690 | Inner |
| 18 | 74 | 75 | 2562.39 | 2559.74 | 87.19 | 0.25 | 0.0304 | Inner |
| 19 | 87 | 73 | 2564.95 | 2564.64 | 90.76 | 0.2 | 0.0034 | Outer |
| 20 | 44 | 33 | 2555.9 | 2555.47 | 77.45 | 0.53 | 0.0056 | Inner |
| 21 | 45 | 46 | 2555.66 | 2554.85 | 64.02 | 0.2 | 0.0127 | Inner |
| 22 | 38 | 49 | 2553.85 | 2553.46 | 119.96 | 0.25 | 0.0033 | Inner |
| 23 | 57 | 58 | 2564.29 | 2563.43 | 64.21 | 0.2 | 0.0134 | Outer |
| 24 | 66 | 49 | 2553.84 | 2553.46 | 100.29 | 0.2 | 0.0038 | Outer |
| 25 | 12 | 13 | 2554.62 | 2554.32 | 70.35 | 0.8 | 0.0043 | Inner |
| 26 | 47 | 48 | 2552.93 | 2552.37 | 71.55 | 0.8 | 0.0078 | Inner |
| 27 | 9 | 10 | 2556.53 | 2555.93 | 106.60 | 0.35 | 0.0056 | Inner |
| 28 | 82 | 83 | 2553.46 | 2552.89 | 93.15 | 0.2 | 0.0061 | Inner |
| 29 | 30 | 31 | 2559.53 | 2558.01 | 80.85 | 0.35 | 0.0188 | Inner |
| 30 | 18 | 25 | 2552.45 | 2550.48 | 84.27 | 0.25 | 0.0234 | Inner |
| 31 | 67 | 50 | 2553.48 | 2553.26 | 100.15 | 0.5 | 0.0022 | Inner |
| 32 | 85 | 95 | 2551.96 | 2551.55 | 83.59 | 0.25 | 0.0049 | Inner |
| 33 | 96 | 97 | 2573.98 | 2568.06 | 186.73 | 0.2 | 0.0317 | Outer |
| 34 | 31 | 22 | 2558.21 | 2557.5 | 75.40 | 0.2 | 0.0094 | Outer |
| 35 | 37 | 48 | 2554.64 | 2554.27 | 120.02 | 0.2 | 0.0031 | Outer |
| 36 | 14 | 36 | 2553.97 | 2553.49 | 92.98 | 0.8 | 0.0052 | Inner |
| 39 | 10 | 11 | 2555.83 | 2555.3 | 99.83 | 0.35 | 0.0053 | Inner |
| 40 | 78 | 79 | 2555.87 | 2554.42 | 99.94 | 0.25 | 0.0145 | Inner |
| 41 | 106 | 107 | 2547.72 | 2545.93 | 101.92 | 0.8 | 0.0176 | Inner |
| 42 | 82 | 93 | 2553.76 | 2553.31 | 89.98 | 0.2 | 0.0050 | Outer |
| 43 | 97 | 98 | 2568.06 | 2563.29 | 197.59 | 0.2 | 0.0241 | Outer |
| 44 | 96 | 86 | 2573.98 | 2571.83 | 100.95 | 0.2 | 0.0213 | Outer |
| 45 | 75 | 60 | 2559.64 | 2559.3 | 71.35 | 0.2 | 0.0048 | Outer |
| 46 | 54 | 26 | 2574.69 | 2571.8 | 167.64 | 0.2 | 0.0172 | Outer |
| 47 | 71 | 72 | 2568.95 | 2566.5 | 93.69 | 0.2 | 0.0262 | Inner |
| 48 | 89 | 76 | 2558.26 | 2557.74 | 82.18 | 0.25 | 0.0063 | Inner |
| 49 | 46 | 35 | 2555.25 | 2554.81 | 115.38 | 0.2 | 0.0038 | Outer |
| 50 | 97 | 87 | 2568.06 | 2564.95 | 95.21 | 0.2 | 0.0327 | Inner |
| 51 | 101 | 102 | 2556.8 | 2554.13 | 87.61 | 0.2 | 0.0305 | Inner |
| 52 | 70 | 71 | 2574.39 | 2568.95 | 58.92 | 0.2 | 0.0927 | Inner |
| 53 | 56 | 28 | 2565.48 | 2564.51 | 168.30 | 0.2 | 0.0058 | Outer |
| 54 | 80 | 81 | 2554.03 | 2553.81 | 85.24 | 0.38 | 0.0026 | Inner |
| 55 | 22 | 23 | 2557.1 | 2556.04 | 86.51 | 0.3 | 0.0123 | Inner |
| 56 | 88 | 75 | 2560.66 | 2559.64 | 87.88 | 0.35 | 0.0116 | Inner |
| 57 | 92 | 103 | 2553.77 | 2553.41 | 95.84 | 0.3 | 0.0038 | Inner |
| 58 | 3 | 4 | 2556.21 | 2555.62 | 174.37 | 0.2 | 0.0034 | Outer |
| 59 | 65 | 48 | 2554.37 | 2553.97 | 100.20 | 0.2 | 0.0040 | Outer |
| 60 | 60 | 43 | 2559.3 | 2557.77 | 106.91 | 0.2 | 0.0143 | Outer |
| 61 | 61 | 44 | 2556.44 | 2555.9 | 100.57 | 0.5 | 0.0054 | Inner |
| 62 | 8 | 1 | 2561.91 | 2560.63 | 94.54 | 0.25 | 0.0135 | Inner |
| 63 | 40 | 41 | 2553.39 | 2552.99 | 93.47 | 0.2 | 0.0043 | Outer |
| 64 | 29 | 30 | 2561.48 | 2559.53 | 68.10 | 0.35 | 0.0286 | Inner |
| 65 | 91 | 102 | 2555.22 | 2554.03 | 100.75 | 0.25 | 0.0118 | Inner |
| 66 | 60 | 61 | 2559.3 | 2556.84 | 98.89 | 0.25 | 0.0249 | Inner |
| 67 | 53 | 52 | 2552.54 | 2552.25 | 76.18 | 0.25 | 0.0038 | Inner |
| 68 | 103 | 104 | 2553.21 | 2552.03 | 101.03 | 0.35 | 0.0117 | Inner |
| 69 | 63 | 64 | 2555.81 | 2554.99 | 80.44 | 0.25 | 0.0102 | Inner |
| 70 | 91 | 92 | 2555.02 | 2554.07 | 169.14 | 0.2 | 0.0056 | Outer |
| 71 | 104 | 105 | 2552.03 | 2550.65 | 90.36 | 0.38 | 0.0153 | Inner |
| 72 | 40 | 51 | 2553.09 | 2552.83 | 91.17 | 0.38 | 0.0029 | Inner |
| 73 | 105 | 106 | 2549.05 | 2547.72 | 79.15 | 0.8 | 0.0168 | Inner |
| 74 | 56 | 57 | 2565.68 | 2564.29 | 77.64 | 0.2 | 0.0179 | Inner |
| 75 | 108 | 109 | 2549.66 | 2549.6 | 92.36 | 1.5 | 0.0007 | Inner |
| 76 | 20 | 8 | 2563.65 | 2561.91 | 60.98 | 0.2 | 0.0285 | Outer |
| 77 | 1 | 2 | 2560.63 | 2557.6 | 185.45 | 0.25 | 0.0163 | Inner |
| 78 | 62 | 45 | 2556.3 | 2555.76 | 100.89 | 0.2 | 0.0054 | Outer |
| 79 | 16 | 38 | 2554.17 | 2553.85 | 89.92 | 0.2 | 0.0036 | Outer |
| 80 | 76 | 77 | 2557.84 | 2556.79 | 99.04 | 0.2 | 0.0106 | Outer |
| 82 | 21 | 22 | 2558.49 | 2557.1 | 128.46 | 0.25 | 0.0108 | Inner |
| 83 | 4 | 13 | 2555.62 | 2555.22 | 97.17 | 0.25 | 0.0041 | Inner |
| 84 | 16 | 17 | 2553.97 | 2551.03 | 71.24 | 0.25 | 0.0413 | Inner |
| 85 | 100 | 90 | 2558.8 | 2557.51 | 99.36 | 0.2 | 0.0130 | Outer |
| 86 | 15 | 16 | 2554.28 | 2553.97 | 71.49 | 0.25 | 0.0043 | Inner |
| 87 | 13 | 35 | 2555.32 | 2554.81 | 94.14 | 0.2 | 0.0054 | Outer |
| 88 | 23 | 10 | 2556.14 | 2555.83 | 70.51 | 0.2 | 0.0044 | Outer |
| 89 | 81 | 67 | 2553.81 | 2553.48 | 75.12 | 0.38 | 0.0044 | Inner |
| 90 | 55 | 27 | 2568.51 | 2566.75 | 174.23 | 0.2 | 0.0101 | Inner |
| 91 | 66 | 67 | 2553.74 | 2553.48 | 71.39 | 0.35 | 0.0036 | Inner |
| 92 | 5 | 6 | 2554.37 | 2553.65 | 154.33 | 0.25 | 0.0047 | Inner |
| 93 | 20 | 21 | 2563.65 | 2558.49 | 79.86 | 0.2 | 0.0648 | Inner |
| 94 | 79 | 80 | 2554.42 | 2554.03 | 83.76 | 0.35 | 0.0047 | Inner |
| 95 | 3 | 11 | 2556.01 | 2555.6 | 79.62 | 0.3 | 0.0052 | Inner |
| 96 | 68 | 51 | 2553.45 | 2553.03 | 101.01 | 0.2 | 0.0042 | Inner |
| 97 | 51 | 52 | 2550.33 | 2549.35 | 93.35 | 0.8 | 0.0105 | Inner |
| 98 | 17 | 39 | 2553.63 | 2553.29 | 116.04 | 0.35 | 0.0029 | Inner |
| 99 | 35 | 36 | 2554.81 | 2554.39 | 71.56 | 0.25 | 0.0059 | Inner |
| 100 | 95 | 107 | 2551.55 | 2550.33 | 97.02 | 0.3 | 0.0126 | Inner |
| 102 | 39 | 40 | 2553.29 | 2553.09 | 92.30 | 0.38 | 0.0022 | Inner |
| 104 | 58 | 30 | 2563.43 | 2559.73 | 178.81 | 0.2 | 0.0207 | Outer |
| 105 | 2 | 9 | 2557.6 | 2556.53 | 84.56 | 0.3 | 0.0127 | Inner |
| 107 | 99 | 89 | 2559.58 | 2558.26 | 99.87 | 0.2 | 0.0132 | Inner |
| 108 | 36 | 47 | 2553.49 | 2552.93 | 117.20 | 0.8 | 0.0048 | Inner |
| 109 | 28 | 29 | 2564.41 | 2561.48 | 74.80 | 0.25 | 0.0392 | Inner |
| 110 | 82 | 68 | 2553.76 | 2553.45 | 69.96 | 0.2 | 0.0044 | Outer |
| 111 | 34 | 12 | 2555.94 | 2555.52 | 122.03 | 0.2 | 0.0034 | Outer |
| 112 | 81 | 82 | 2554.01 | 2553.46 | 90.88 | 0.2 | 0.0061 | Outer |
| 113 | 14 | 15 | 2554.67 | 2554.38 | 71.37 | 0.2 | 0.0041 | Outer |
| 114 | 72 | 73 | 2566.5 | 2564.54 | 97.08 | 0.2 | 0.0202 | Inner |
| 115 | 64 | 47 | 2555.09 | 2554.73 | 99.99 | 0.2 | 0.0036 | Outer |
| 116 | 100 | 101 | 2558.8 | 2556.8 | 99.49 | 0.2 | 0.0201 | Inner |
| 117 | 49 | 50 | 2551.76 | 2551.16 | 71.54 | 0.8 | 0.0084 | Inner |
| 118 | 94 | 105 | 2550.41 | 2549.05 | 103.08 | 0.8 | 0.0132 | Inner |
| 119 | 72 | 56 | 2566.5 | 2565.68 | 76.64 | 0.2 | 0.0107 | Outer |
| 120 | 27 | 28 | 2566.75 | 2564.41 | 72.37 | 0.25 | 0.0324 | Inner |
| 121 | 7 | 8 | 2567.36 | 2561.91 | 151.45 | 0.2 | 0.0360 | Inner |
| 122 | 28 | 20 | 2564.51 | 2563.65 | 75.14 | 0.2 | 0.0114 | Outer |
| 123 | 34 | 45 | 2555.94 | 2555.66 | 88.83 | 0.2 | 0.0032 | Outer |
| 124 | 23 | 24 | 2556.04 | 2555.6 | 100.09 | 0.35 | 0.0044 | Inner |
| 125 | 43 | 32 | 2557.77 | 2556.7 | 71.96 | 0.2 | 0.0149 | Outer |
| 126 | 94 | 95 | 2552.71 | 2551.85 | 186.59 | 0.2 | 0.0046 | Outer |
| 127 | 4 | 5 | 2556.22 | 2554.37 | 199.28 | 0.2 | 0.0093 | Outer |
| 128 | 50 | 51 | 2551.16 | 2550.33 | 92.13 | 0.8 | 0.0090 | Inner |
| 129 | 59 | 60 | 2561.04 | 2559.3 | 67.83 | 0.2 | 0.0257 | Inner |
| 130 | 32 | 33 | 2556.4 | 2555.57 | 94.71 | 0.45 | 0.0088 | Inner |
| 131 | 71 | 55 | 2568.95 | 2568.51 | 76.60 | 0.2 | 0.0057 | Outer |
| 132 | 37 | 15 | 2554.64 | 2554.28 | 89.70 | 0.2 | 0.0040 | Outer |
| 133 | 99 | 100 | 2559.38 | 2558.8 | 94.94 | 0.2 | 0.0061 | Outer |
| 134 | 42 | 29 | 2563.03 | 2561.58 | 99.84 | 0.3 | 0.0145 | Inner |
| 135 | 50 | 39 | 2553.56 | 2550.89 | 91.69 | 0.2 | 0.0291 | Outer |
| 136 | 86 | 87 | 2571.83 | 2564.95 | 191.59 | 0.2 | 0.0359 | Inner |
| 137 | 90 | 77 | 2557.21 | 2556.79 | 80.04 | 0.2 | 0.0052 | Outer |
| 138 | 48 | 49 | 2552.37 | 2551.76 | 71.38 | 0.8 | 0.0085 | Inner |
| 139 | 2 | 3 | 2557.3 | 2556.01 | 218.32 | 0.25 | 0.0059 | Outer |
| 140 | 25 | 41 | 2553.08 | 2552.89 | 73.08 | 0.35 | 0.0026 | Inner |
| 141 | 41 | 52 | 2552.89 | 2552.45 | 92.74 | 0.35 | 0.0047 | Inner |
| 142 | 73 | 57 | 2564.74 | 2564.29 | 75.83 | 0.2 | 0.0059 | Outer |
| 143 | 52 | 83 | 2550.65 | 2548.49 | 173.46 | 0.8 | 0.0125 | Inner |
| 145 | 64 | 65 | 2554.99 | 2554.17 | 71.42 | 0.25 | 0.0115 | Inner |
| 146 | 11 | 12 | 2555 | 2554.62 | 103.54 | 0.8 | 0.0037 | Inner |
| 147 | 43 | 44 | 2557.77 | 2556.2 | 98.88 | 0.2 | 0.0159 | Inner |
| 148 | 13 | 14 | 2554.32 | 2553.97 | 71.89 | 0.8 | 0.0049 | Inner |
| 149 | 81 | 92 | 2554.11 | 2553.77 | 84.78 | 0.2 | 0.0040 | Outer |
| 150 | 69 | 53 | 2552.36 | 2549.94 | 91.63 | 0.2 | 0.0264 | Inner |
| 151 | 83 | 94 | 2549.29 | 2548.21 | 79.35 | 0.8 | 0.0136 | Inner |
| 152 | 31 | 32 | 2558.01 | 2556.4 | 74.43 | 0.35 | 0.0216 | Inner |
| 153 | 6 | 18 | 2553.65 | 2552.45 | 115.31 | 0.25 | 0.0104 | Inner |
| 154 | 98 | 88 | 2563.29 | 2560.76 | 95.78 | 0.2 | 0.0264 | Outer |
| 155 | 46 | 47 | 2554.85 | 2554.53 | 71.57 | 0.3 | 0.0045 | Inner |
| 156 | 33 | 24 | 2555.47 | 2555.2 | 74.33 | 0.7 | 0.0036 | Inner |
| 157 | 77 | 78 | 2556.79 | 2555.87 | 87.30 | 0.25 | 0.0105 | Inner |
| 158 | 62 | 63 | 2556.5 | 2555.81 | 63.63 | 0.2 | 0.0108 | Inner |
| 161 | 65 | 66 | 2554.17 | 2553.74 | 71.43 | 0.3 | 0.0060 | Inner |
| 162 | 63 | 46 | 2555.71 | 2555.25 | 91.45 | 0.2 | 0.0050 | Outer |
| 163 | 57 | 42 | 2564.29 | 2563.03 | 74.51 | 0.25 | 0.0169 | Inner |
| 164 | 54 | 70 | 2574.69 | 2574.39 | 74.70 | 0.2 | 0.0040 | Outer |
| 165 | 84 | 69 | 2552.83 | 2552.36 | 84.26 | 0.2 | 0.0056 | Outer |
| 166 | 102 | 103 | 2554.03 | 2553.21 | 172.58 | 0.35 | 0.0048 | Inner |
| 167 | 77 | 62 | 2556.79 | 2556.5 | 75.00 | 0.2 | 0.0039 | Outer |
| 168 | 107 | 108 | 2547.13 | 2545.66 | 80.99 | 0.8 | 0.0182 | Inner |
| 169 | 93 | 104 | 2553.31 | 2552.93 | 96.66 | 0.25 | 0.0039 | Inner |

Table 3. Design of the pumping stations of the Chicó Sur C1 network.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Location (manhole)** | **Upstream invert elevation (m)** | **Downstream invert elevation (m)** | **Pumping height (m)** | **Pumping flow rate (m3/s)** |
| 17 | 2551.03 | 2553.63 | 2.6 | 0.04 |
| 25 | 2550.48 | 2553.08 | 2.6 | 0.05 |
| 39 | 2550.89 | 2553.49 | 2.6 | 0.06 |
| 52 | 2549.35 | 2551.95 | 2.6 | 1.24 |
| 53 | 2549.94 | 2552.54 | 2.6 | 0.02 |
| 83 | 2548.69 | 2551.49 | 2.8 | 1.26 |
| 94 | 2548.21 | 2551.61 | 3.4 | 1.28 |
| 107 | 2545.93 | 2548.53 | 2.6 | 1.51 |
| 108 | 2547.06 | 2549.66 | 2.6 | 1.53 |

1. **Flattened Chicó C1 Network**
   1. Input data

Table 4 presents the input data required to design the Chicó C1 network. These data include the inflow, ground elevation and x, y coordinates at each manhole.

Table 4. Input data of the Flattened Chicó C1 network.

| **Manholes** | **Coordinate X (m)** | **Coordinate Y (m)** | **Ground elevation (m)** | **Inflow (m³/s)** |
| --- | --- | --- | --- | --- |
| 1 | 2145.39 | 7352.39 | 2000 | 0.012 |
| 2 | 1982.51 | 7441.01 | 2000 | 0.022 |
| 3 | 1784.49 | 7532.93 | 2000 | 0.022 |
| 4 | 1632.28 | 7617.99 | 2000 | 0.021 |
| 5 | 1452.89 | 7704.76 | 2000 | 0.016 |
| 6 | 1317.86 | 7779.49 | 2000 | 0.012 |
| 7 | 2233.12 | 7204.6 | 2000 | 0.011 |
| 8 | 2097.16 | 7271.09 | 2000 | 0.015 |
| 9 | 1932.99 | 7372.47 | 2000 | 0.013 |
| 10 | 1835.94 | 7416.57 | 2000 | 0.013 |
| 11 | 1747.32 | 7462.52 | 2000 | 0.018 |
| 12 | 1650.5 | 7499.21 | 2000 | 0.014 |
| 13 | 1588 | 7531.5 | 2000 | 0.017 |
| 14 | 1524.17 | 7564.57 | 2000 | 0.013 |
| 15 | 1460.84 | 7597.47 | 2000 | 0.013 |
| 16 | 1397.46 | 7630.55 | 2000 | 0.013 |
| 17 | 1333.26 | 7661.29 | 2000 | 0.009 |
| 18 | 1202.87 | 7770.98 | 2000 | 0.009 |
| 19 | 2204.2 | 7149.6 | 2000 | 0.011 |
| 20 | 2065.54 | 7218.98 | 2000 | 0.02 |
| 21 | 1996.74 | 7259.19 | 2000 | 0.01 |
| 22 | 1880.41 | 7313.67 | 2000 | 0.019 |
| 23 | 1803.79 | 7353.82 | 2000 | 0.013 |
| 24 | 1715.03 | 7400.08 | 2000 | 0.013 |
| 25 | 1144.17 | 7710.55 | 2000 | 0.009 |
| 26 | 2157.49 | 7087.17 | 2000 | 0.012 |
| 27 | 2093.6 | 7119.76 | 2000 | 0.016 |
| 28 | 2029.41 | 7153.1 | 2000 | 0.02 |
| 29 | 1963.14 | 7187.67 | 2000 | 0.013 |
| 30 | 1905.84 | 7224.42 | 2000 | 0.004 |
| 31 | 1831.54 | 7256.25 | 2000 | 0.021 |
| 32 | 1765.15 | 7289.85 | 2000 | 0.013 |
| 33 | 1681.29 | 7333.85 | 2000 | 0.013 |
| 34 | 1600.04 | 7388.1 | 2000 | 0.009 |
| 35 | 1544.46 | 7448.03 | 2000 | 0.014 |
| 36 | 1481.47 | 7481.98 | 2000 | 0.014 |
| 37 | 1419.46 | 7517.89 | 2000 | 0.009 |
| 38 | 1356.12 | 7550.7 | 2000 | 0.009 |
| 39 | 1279.69 | 7558.36 | 2000 | 0.013 |
| 40 | 1197.64 | 7600.63 | 2000 | 0.012 |
| 41 | 1114.68 | 7643.68 | 2000 | 0.013 |
| 42 | 1917.32 | 7098.98 | 2000 | 0.009 |
| 43 | 1735.7 | 7224.2 | 2000 | 0.013 |
| 44 | 1645.68 | 7265.07 | 2000 | 0.013 |
| 45 | 1548.16 | 7315.99 | 2000 | 0.013 |
| 46 | 1491.4 | 7345.58 | 2000 | 0.018 |
| 47 | 1427.55 | 7377.92 | 2000 | 0.018 |
| 48 | 1364.27 | 7411.31 | 2000 | 0.018 |
| 49 | 1300.92 | 7444.2 | 2000 | 0.018 |
| 50 | 1237.38 | 7477.06 | 2000 | 0.017 |
| 51 | 1155.71 | 7519.68 | 2000 | 0.017 |
| 52 | 1072.14 | 7561.27 | 2000 | 0.02 |
| 53 | 1004.44 | 7596.19 | 2000 | 0.008 |
| 54 | 2090.9 | 6933.35 | 2000 | 0.012 |
| 55 | 2013.31 | 6965.14 | 2000 | 0.012 |
| 56 | 1954.28 | 7002.5 | 2000 | 0.016 |
| 57 | 1882.86 | 7032.93 | 2000 | 0.017 |
| 58 | 1826.73 | 7064.1 | 2000 | 0.008 |
| 59 | 1746.82 | 7099.01 | 2000 | 0.016 |
| 60 | 1686.22 | 7129.44 | 2000 | 0.018 |
| 61 | 1599.01 | 7175.99 | 2000 | 0.013 |
| 62 | 1508.1 | 7223.4 | 2000 | 0.013 |
| 63 | 1456.74 | 7260.95 | 2000 | 0.013 |
| 64 | 1381.43 | 7289.2 | 2000 | 0.013 |
| 65 | 1318.17 | 7322.35 | 2000 | 0.013 |
| 66 | 1254.73 | 7355.18 | 2000 | 0.013 |
| 67 | 1191.38 | 7388.1 | 2000 | 0.013 |
| 68 | 1109.34 | 7429.94 | 2000 | 0.009 |
| 69 | 962.53 | 7514.74 | 2000 | 0.008 |
| 70 | 2056.96 | 6866.81 | 2000 | 0.009 |
| 71 | 2002.76 | 6889.27 | 2000 | 0.017 |
| 72 | 1920.35 | 6933.78 | 2000 | 0.013 |
| 73 | 1832.9 | 6975.88 | 2000 | 0.018 |
| 74 | 1728.08 | 7031.72 | 2000 | 0.009 |
| 75 | 1649.08 | 7068.52 | 2000 | 0.016 |
| 76 | 1559.39 | 7112.63 | 2000 | 0.017 |
| 77 | 1471.37 | 7158.01 | 2000 | 0.017 |
| 78 | 1393.92 | 7198.28 | 2000 | 0.008 |
| 79 | 1305.24 | 7244.35 | 2000 | 0.013 |
| 80 | 1230.89 | 7282.92 | 2000 | 0.009 |
| 81 | 1155.26 | 7322.23 | 2000 | 0.017 |
| 82 | 1076.77 | 7368.03 | 2000 | 0.016 |
| 83 | 992.3 | 7407.29 | 2000 | 0.02 |
| 84 | 913.3 | 7446.36 | 2000 | 0.013 |
| 85 | 826.81 | 7493.27 | 2000 | 0.009 |
| 86 | 1958.45 | 6815.65 | 2000 | 0.017 |
| 87 | 1785.75 | 6898.33 | 2000 | 0.026 |
| 88 | 1604.82 | 6992.61 | 2000 | 0.017 |
| 89 | 1530.58 | 7035.67 | 2000 | 0.009 |
| 90 | 1434.47 | 7086.98 | 2000 | 0.017 |
| 91 | 1268.27 | 7173.47 | 2000 | 0.025 |
| 92 | 1116 | 7247.09 | 2000 | 0.016 |
| 93 | 1035.11 | 7288.28 | 2000 | 0.008 |
| 94 | 955.69 | 7336.9 | 2000 | 0.017 |
| 95 | 788.2 | 7419.13 | 2000 | 0.017 |
| 96 | 1910.25 | 6726.98 | 2000 | 0.013 |
| 97 | 1744.42 | 6812.62 | 2000 | 0.021 |
| 98 | 1569.16 | 6903.75 | 2000 | 0.018 |
| 99 | 1475.04 | 6952.68 | 2000 | 0.013 |
| 100 | 1391.34 | 6997.48 | 2000 | 0.013 |
| 101 | 1302.31 | 7041.85 | 2000 | 0.008 |
| 102 | 1224.8 | 7082.59 | 2000 | 0.016 |
| 103 | 1071.64 | 7162.13 | 2000 | 0.016 |
| 104 | 981.54 | 7207.82 | 2000 | 0.013 |
| 105 | 901.3 | 7249.35 | 2000 | 0.013 |
| 106 | 831.25 | 7286.18 | 2000 | 0.009 |
| 107 | 741.36 | 7334.18 | 2000 | 0.013 |
| 108 | 667.44 | 7367.24 | 2000 | 0.017 |
| 109 | 584.86 | 7408.61 | 2000 | - |

* 1. Final design

Table 5. Design of the Flattened Chicó C1 network*.*

| **ID Pipe** | **Upstream manhole** | **Downstream manhole** | **Upstream invert elevation (m)** | **Downstream invert elevation (m)** | **Length** | **Diameter (m)** | **Slope (-)** | **Type Pipe** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 21 | 20 | 1998.4 | 1996.2 | 79.72 | 0.2 | 0.0276 | Inner |
| 2 | 4 | 13 | 1998.2 | 1997.9 | 97.17 | 0.2 | 0.0031 | Inner |
| 3 | 29 | 30 | 1998.3 | 1998.2 | 68.07 | 0.8 | 0.0015 | Inner |
| 4 | 3 | 2 | 1998.8 | 1998.3 | 218.32 | 0.35 | 0.0023 | Inner |
| 5 | 95 | 107 | 1995.4 | 1995.3 | 97.01 | 1.35 | 0.0010 | Inner |
| 6 | 104 | 93 | 1998.8 | 1998.5 | 96.66 | 0.2 | 0.0031 | Outer |
| 7 | 48 | 49 | 1997.3 | 1997.1 | 71.38 | 0.38 | 0.0028 | Inner |
| 8 | 88 | 87 | 1998.8 | 1998.1 | 204.02 | 0.2 | 0.0034 | Outer |
| 9 | 66 | 49 | 1998.1 | 1997.8 | 100.29 | 0.35 | 0.0030 | Inner |
| 10 | 4 | 3 | 1998.8 | 1996.2 | 174.38 | 0.2 | 0.0149 | Outer |
| 11 | 11 | 3 | 1998.8 | 1996.2 | 79.66 | 0.2 | 0.0327 | Outer |
| 12 | 92 | 91 | 1998.8 | 1998.2 | 169.13 | 0.2 | 0.0035 | Outer |
| 13 | 64 | 47 | 1998.8 | 1998.5 | 99.99 | 0.2 | 0.0030 | Outer |
| 14 | 76 | 77 | 1998.1 | 1997.7 | 99.03 | 0.25 | 0.0040 | Inner |
| 15 | 23 | 10 | 1998.8 | 1998.5 | 70.51 | 0.2 | 0.0043 | Outer |
| 16 | 85 | 95 | 1995.5 | 1995.4 | 83.59 | 1.35 | 0.0012 | Inner |
| 17 | 36 | 14 | 1998.4 | 1998.2 | 92.98 | 0.25 | 0.0022 | Inner |
| 19 | 30 | 31 | 1998.2 | 1998.1 | 80.83 | 0.8 | 0.0012 | Inner |
| 20 | 37 | 48 | 1997.6 | 1997.3 | 120.02 | 0.35 | 0.0025 | Inner |
| 21 | 58 | 59 | 1998 | 1997.8 | 87.20 | 0.35 | 0.0023 | Inner |
| 22 | 13 | 35 | 1997.5 | 1997.4 | 94.14 | 1 | 0.0011 | Inner |
| 23 | 96 | 86 | 1998 | 1997.7 | 100.92 | 0.35 | 0.0030 | Inner |
| 24 | 102 | 103 | 1996.6 | 1996.5 | 172.58 | 1.35 | 0.0006 | Inner |
| 25 | 102 | 101 | 1998.8 | 1998.5 | 87.57 | 0.2 | 0.0034 | Outer |
| 26 | 72 | 71 | 1998.8 | 1998.5 | 93.66 | 0.2 | 0.0032 | Outer |
| 27 | 92 | 81 | 1996.4 | 1996.3 | 84.78 | 1.35 | 0.0012 | Inner |
| 28 | 52 | 53 | 1995.9 | 1995.8 | 76.18 | 1.35 | 0.0013 | Inner |
| 29 | 39 | 40 | 1998.5 | 1998.2 | 92.30 | 0.25 | 0.0033 | Inner |
| 30 | 58 | 30 | 1998.8 | 1998.2 | 178.78 | 0.2 | 0.0034 | Outer |
| 31 | 55 | 27 | 1997.1 | 1996.6 | 174.22 | 0.5 | 0.0029 | Inner |
| 32 | 16 | 38 | 1998.1 | 1997.8 | 89.92 | 0.3 | 0.0033 | Inner |
| 33 | 50 | 39 | 1998.8 | 1998.5 | 91.65 | 0.2 | 0.0033 | Outer |
| 34 | 46 | 63 | 1997.3 | 1997.2 | 91.45 | 1.05 | 0.0011 | Inner |
| 35 | 69 | 84 | 1995.7 | 1995.6 | 84.26 | 1.35 | 0.0012 | Inner |
| 36 | 97 | 96 | 1998.7 | 1998 | 186.64 | 0.25 | 0.0038 | Outer |
| 37 | 11 | 12 | 1997.7 | 1997.6 | 103.54 | 1 | 0.0010 | Inner |
| 38 | 42 | 29 | 1998.8 | 1998.5 | 99.83 | 0.25 | 0.0030 | Inner |
| 39 | 63 | 62 | 1997.2 | 1997.1 | 63.62 | 1.05 | 0.0016 | Inner |
| 40 | 83 | 52 | 1998.5 | 1998 | 173.45 | 0.3 | 0.0029 | Inner |
| 41 | 77 | 78 | 1997 | 1996.9 | 87.29 | 1.05 | 0.0011 | Inner |
| 42 | 49 | 50 | 1997.1 | 1997 | 71.53 | 0.6 | 0.0014 | Inner |
| 43 | 78 | 79 | 1996.9 | 1996.8 | 99.93 | 1.2 | 0.0010 | Inner |
| 44 | 71 | 55 | 1997.3 | 1997.1 | 76.60 | 0.5 | 0.0026 | Inner |
| 45 | 15 | 37 | 1997.9 | 1997.6 | 89.70 | 0.3 | 0.0033 | Inner |
| 46 | 22 | 21 | 1998.8 | 1998.4 | 128.46 | 0.2 | 0.0031 | Outer |
| 47 | 40 | 51 | 1998.2 | 1997.9 | 91.17 | 0.3 | 0.0033 | Inner |
| 48 | 8 | 20 | 1998.8 | 1998.6 | 60.95 | 0.35 | 0.0033 | Inner |
| 49 | 67 | 66 | 1998.8 | 1998.5 | 71.39 | 0.2 | 0.0042 | Outer |
| 50 | 45 | 62 | 1998.1 | 1997.7 | 100.89 | 0.25 | 0.0040 | Inner |
| 51 | 93 | 82 | 1998.5 | 1998.2 | 89.98 | 0.25 | 0.0033 | Inner |
| 52 | 44 | 43 | 1998.6 | 1998.4 | 98.86 | 0.5 | 0.0020 | Inner |
| 53 | 19 | 20 | 1998.6 | 1996.2 | 155.07 | 0.2 | 0.0155 | Inner |
| 54 | 5 | 4 | 1998.8 | 1998.2 | 199.27 | 0.2 | 0.0030 | Outer |
| 55 | 98 | 99 | 1998 | 1997.7 | 106.08 | 0.35 | 0.0028 | Inner |
| 56 | 104 | 103 | 1998.8 | 1998.4 | 101.02 | 0.2 | 0.0040 | Outer |
| 57 | 2 | 1 | 1998.8 | 1998.2 | 185.43 | 0.2 | 0.0032 | Outer |
| 58 | 101 | 100 | 1998.5 | 1998.2 | 99.47 | 0.25 | 0.0030 | Inner |
| 59 | 1 | 8 | 1998.2 | 1996.2 | 94.55 | 0.2 | 0.0212 | Inner |
| 60 | 12 | 34 | 1998.8 | 1998.4 | 122.03 | 0.2 | 0.0033 | Outer |
| 61 | 31 | 22 | 1998.1 | 1998 | 75.40 | 0.9 | 0.0013 | Inner |
| 62 | 59 | 31 | 1998.8 | 1998.2 | 178.61 | 0.2 | 0.0034 | Outer |
| 63 | 47 | 46 | 1998.8 | 1998.5 | 71.57 | 0.2 | 0.0042 | Outer |
| 64 | 41 | 52 | 1997.3 | 1997.1 | 92.74 | 0.35 | 0.0022 | Inner |
| 65 | 98 | 97 | 1998.8 | 1998.2 | 197.54 | 0.2 | 0.0030 | Outer |
| 66 | 18 | 25 | 1997.8 | 1997.5 | 84.25 | 0.3 | 0.0036 | Inner |
| 67 | 88 | 98 | 1998.3 | 1998 | 95.75 | 0.3 | 0.0031 | Inner |
| 69 | 81 | 67 | 1998.8 | 1998.5 | 75.12 | 0.2 | 0.0040 | Outer |
| 70 | 9 | 10 | 1997.9 | 1997.8 | 106.60 | 1 | 0.0009 | Inner |
| 71 | 53 | 69 | 1995.8 | 1995.7 | 91.60 | 1.35 | 0.0011 | Inner |
| 72 | 86 | 71 | 1997.5 | 1997.3 | 85.93 | 0.5 | 0.0023 | Inner |
| 73 | 45 | 46 | 1998.8 | 1998.6 | 64.01 | 0.2 | 0.0031 | Outer |
| 74 | 14 | 15 | 1998.2 | 1997.9 | 71.37 | 0.3 | 0.0042 | Inner |
| 75 | 38 | 49 | 1997.8 | 1997.5 | 119.96 | 0.35 | 0.0025 | Inner |
| 76 | 64 | 65 | 1998.8 | 1998.5 | 71.42 | 0.2 | 0.0042 | Outer |
| 77 | 76 | 75 | 1998.8 | 1998.5 | 99.95 | 0.2 | 0.0030 | Outer |
| 78 | 84 | 83 | 1998.8 | 1998.5 | 88.13 | 0.2 | 0.0034 | Outer |
| 79 | 74 | 75 | 1998.8 | 1998.5 | 87.15 | 0.2 | 0.0034 | Outer |
| 80 | 94 | 95 | 1998.3 | 1997.7 | 186.59 | 0.3 | 0.0032 | Inner |
| 81 | 68 | 51 | 1996.1 | 1996 | 101.01 | 1.35 | 0.0010 | Inner |
| 82 | 26 | 27 | 1998.8 | 1996.2 | 71.77 | 0.2 | 0.0363 | Outer |
| 83 | 6 | 18 | 1998.2 | 1997.8 | 115.31 | 0.3 | 0.0035 | Inner |
| 84 | 75 | 88 | 1998.7 | 1998.3 | 87.87 | 0.25 | 0.0046 | Outer |
| 85 | 105 | 94 | 1998.8 | 1998.3 | 103.07 | 0.2 | 0.0049 | Outer |
| 86 | 91 | 102 | 1996.7 | 1996.6 | 100.74 | 1.2 | 0.0010 | Inner |
| 87 | 60 | 61 | 1997.6 | 1997.3 | 98.86 | 0.38 | 0.0030 | Inner |
| 88 | 28 | 29 | 1998.5 | 1998.3 | 74.75 | 0.7 | 0.0027 | Inner |
| 89 | 5 | 6 | 1998.8 | 1998.2 | 154.33 | 0.2 | 0.0039 | Outer |
| 90 | 7 | 19 | 1998.8 | 1998.6 | 62.14 | 0.2 | 0.0032 | Outer |
| 91 | 73 | 87 | 1998.4 | 1998.1 | 90.76 | 0.3 | 0.0033 | Inner |
| 92 | 106 | 107 | 1998.2 | 1997.8 | 101.90 | 0.2 | 0.0039 | Inner |
| 93 | 79 | 80 | 1998.8 | 1998.5 | 83.76 | 0.2 | 0.0036 | Outer |
| 94 | 105 | 106 | 1998.5 | 1998.2 | 79.14 | 0.2 | 0.0038 | Inner |
| 95 | 75 | 60 | 1998.5 | 1998.2 | 71.35 | 0.2 | 0.0042 | Inner |
| 96 | 50 | 51 | 1997 | 1996.8 | 92.12 | 0.6 | 0.0022 | Inner |
| 97 | 59 | 60 | 1997.8 | 1997.6 | 67.81 | 0.35 | 0.0029 | Inner |
| 98 | 89 | 76 | 1998.4 | 1998.1 | 82.18 | 0.25 | 0.0037 | Inner |
| 99 | 24 | 11 | 1998.8 | 1998.5 | 70.30 | 0.2 | 0.0043 | Outer |
| 100 | 10 | 11 | 1997.8 | 1997.7 | 99.82 | 1 | 0.0010 | Inner |
| 101 | 103 | 92 | 1996.5 | 1996.4 | 95.84 | 1.35 | 0.0010 | Inner |
| 102 | 104 | 105 | 1998.8 | 1998.5 | 90.35 | 0.2 | 0.0033 | Outer |
| 103 | 26 | 54 | 1998.8 | 1998.2 | 167.62 | 0.2 | 0.0036 | Outer |
| 104 | 65 | 66 | 1998.4 | 1998.1 | 71.43 | 0.25 | 0.0042 | Inner |
| 105 | 54 | 70 | 1998.2 | 1998 | 74.70 | 0.25 | 0.0027 | Inner |
| 106 | 87 | 86 | 1997.9 | 1997.5 | 191.47 | 0.38 | 0.0021 | Inner |
| 107 | 27 | 28 | 1996.6 | 1995.9 | 72.34 | 0.5 | 0.0097 | Inner |
| 108 | 82 | 68 | 1996.2 | 1996.1 | 69.95 | 1.35 | 0.0014 | Inner |
| 109 | 2 | 9 | 1998.3 | 1998.1 | 84.56 | 0.38 | 0.0024 | Inner |
| 110 | 80 | 81 | 1998.5 | 1998.2 | 85.24 | 0.25 | 0.0035 | Inner |
| 111 | 15 | 16 | 1998.8 | 1998.5 | 71.49 | 0.2 | 0.0042 | Outer |
| 112 | 72 | 73 | 1998.8 | 1998.5 | 97.06 | 0.2 | 0.0031 | Outer |
| 113 | 81 | 82 | 1996.3 | 1996.2 | 90.88 | 1.35 | 0.0011 | Inner |
| 115 | 20 | 28 | 1998.6 | 1998.5 | 75.14 | 0.5 | 0.0013 | Inner |
| 117 | 64 | 63 | 1998.8 | 1998.5 | 80.43 | 0.2 | 0.0037 | Outer |
| 118 | 34 | 45 | 1998.4 | 1998.1 | 88.83 | 0.25 | 0.0034 | Inner |
| 119 | 107 | 108 | 1995.3 | 1995.2 | 80.98 | 1.35 | 0.0012 | Inner |
| 120 | 44 | 33 | 1998.8 | 1998.5 | 77.45 | 0.2 | 0.0039 | Outer |
| 121 | 24 | 33 | 1998.8 | 1998.5 | 74.33 | 0.25 | 0.0040 | Inner |
| 122 | 23 | 22 | 1998.8 | 1998.5 | 86.50 | 0.2 | 0.0035 | Outer |
| 123 | 67 | 50 | 1998.5 | 1998.1 | 100.15 | 0.25 | 0.0040 | Inner |
| 124 | 100 | 90 | 1997.4 | 1997.2 | 99.35 | 0.4 | 0.0020 | Inner |
| 125 | 99 | 89 | 1998.7 | 1998.4 | 99.86 | 0.25 | 0.0030 | Outer |
| 126 | 76 | 61 | 1998.8 | 1998.5 | 74.73 | 0.2 | 0.0040 | Outer |
| 127 | 47 | 36 | 1998.8 | 1998.4 | 117.20 | 0.2 | 0.0034 | Outer |
| 128 | 43 | 32 | 1998.4 | 1998.2 | 71.95 | 0.5 | 0.0028 | Inner |
| 129 | 57 | 42 | 1998.8 | 1996.2 | 74.54 | 0.2 | 0.0349 | Outer |
| 130 | 72 | 56 | 1998.8 | 1998.5 | 76.64 | 0.2 | 0.0039 | Outer |
| 131 | 41 | 40 | 1998.8 | 1998.5 | 93.47 | 0.2 | 0.0032 | Outer |
| 132 | 56 | 57 | 1998.5 | 1998.2 | 77.63 | 0.25 | 0.0039 | Inner |
| 134 | 39 | 17 | 1998.8 | 1998.4 | 116.04 | 0.2 | 0.0034 | Outer |
| 135 | 25 | 41 | 1997.5 | 1997.3 | 73.08 | 0.35 | 0.0027 | Inner |
| 136 | 94 | 83 | 1998.8 | 1998.5 | 79.34 | 0.2 | 0.0038 | Outer |
| 137 | 84 | 85 | 1995.6 | 1995.5 | 98.39 | 1.35 | 0.0010 | Inner |
| 138 | 60 | 43 | 1998.8 | 1998.4 | 106.90 | 0.2 | 0.0037 | Outer |
| 139 | 35 | 46 | 1997.4 | 1997.3 | 115.37 | 1.05 | 0.0009 | Inner |
| 141 | 32 | 31 | 1998.2 | 1998.1 | 74.41 | 0.6 | 0.0013 | Inner |
| 142 | 56 | 28 | 1998.8 | 1996.2 | 168.32 | 0.2 | 0.0154 | Outer |
| 143 | 74 | 73 | 1998.8 | 1998.4 | 118.77 | 0.2 | 0.0034 | Outer |
| 144 | 14 | 13 | 1998.8 | 1998.5 | 71.89 | 0.2 | 0.0042 | Outer |
| 145 | 61 | 44 | 1997.3 | 1996 | 100.57 | 0.38 | 0.0129 | Inner |
| 146 | 48 | 65 | 1998.8 | 1998.4 | 100.20 | 0.2 | 0.0040 | Outer |
| 147 | 22 | 9 | 1998 | 1997.9 | 78.88 | 1 | 0.0013 | Inner |
| 148 | 33 | 32 | 1998.5 | 1998.2 | 94.70 | 0.3 | 0.0032 | Inner |
| 150 | 82 | 83 | 1998.8 | 1998.5 | 93.15 | 0.2 | 0.0032 | Outer |
| 151 | 62 | 77 | 1997.1 | 1997 | 75.00 | 1.05 | 0.0013 | Inner |
| 152 | 12 | 13 | 1997.6 | 1997.5 | 70.35 | 1 | 0.0014 | Inner |
| 153 | 36 | 35 | 1998.8 | 1998.5 | 71.56 | 0.2 | 0.0042 | Outer |
| 154 | 70 | 71 | 1998 | 1997.8 | 58.67 | 0.3 | 0.0034 | Inner |
| 155 | 17 | 16 | 1998.4 | 1998.1 | 71.18 | 0.2 | 0.0042 | Inner |
| 156 | 99 | 100 | 1997.7 | 1997.4 | 94.94 | 0.35 | 0.0032 | Inner |
| 157 | 47 | 48 | 1998.5 | 1998.2 | 71.55 | 0.2 | 0.0042 | Inner |
| 158 | 79 | 91 | 1996.8 | 1996.7 | 79.94 | 1.2 | 0.0013 | Inner |
| 159 | 73 | 57 | 1998.8 | 1998.5 | 75.83 | 0.2 | 0.0040 | Outer |
| 160 | 108 | 109 | 1995.2 | 1995.1 | 92.36 | 1.35 | 0.0011 | Inner |
| 162 | 90 | 77 | 1998.8 | 1998.5 | 80.04 | 0.2 | 0.0037 | Outer |
| 163 | 57 | 58 | 1998.2 | 1998 | 64.20 | 0.35 | 0.0031 | Inner |
| 164 | 97 | 87 | 1998.2 | 1997.9 | 95.15 | 0.2 | 0.0032 | Inner |
| 165 | 51 | 52 | 1996 | 1995.9 | 93.35 | 1.35 | 0.0011 | Inner |
| 166 | 23 | 24 | 1998.8 | 1996.2 | 100.13 | 0.2 | 0.0260 | Outer |
| 167 | 7 | 8 | 1998.8 | 1996.2 | 151.37 | 0.2 | 0.0172 | Outer |
| 168 | 90 | 91 | 1997.2 | 1996.9 | 187.36 | 0.45 | 0.0016 | Inner |

Table 6. Design of the pumping stations of the Flattened Chicó C1 network.

| **Location (manhole)** | **Upstream invert elevation (m)** | **Downstream invert elevation (m)** | **Pumping height (m)** | **Pumping flow rate (m3/s)** |
| --- | --- | --- | --- | --- |
| 3 | 1996.2 | 1998.8 | 2.6 | 0.04625 |
| 8 | 1996.2 | 1998.8 | 2.6 | 0.04075 |
| 20 | 1996.2 | 1998.8 | 2.6 | 0.08925 |
| 24 | 1996.2 | 1998.8 | 2.6 | 0.01625 |
| 27 | 1996.2 | 1998.8 | 2.6 | 0.1905 |
| 28 | 1995.9 | 1998.5 | 2.6 | 0.30375 |
| 42 | 1996.2 | 1998.8 | 2.6 | 0.01325 |
| 44 | 1996 | 1998.6 | 2.6 | 0.10925 |

1. **Moeini & Afshar C1 Network**
   1. Input data

Table 7 presents the input data required to design the Moeini & Afshar C1 network. These data include the inflow, ground elevation and x, y coordinates at each manhole.

Table 7. Input data of the Moeini & Afahar C1 network.

| **Manholes** | **Coordinate X (m)** | **Coordinate Y (m)** | **Ground elevation (m)** | **Inflow (m³/s)** |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 1000 | 0.00648 |
| 2 | 100 | 0 | 1000 | 0.00648 |
| 3 | 200 | 0 | 1000 | 0.00648 |
| 4 | 300 | 0 | 1000 | 0.00648 |
| 5 | 400 | 0 | 1000 | 0.00648 |
| 6 | 500 | 0 | 1000 | 0.00648 |
| 7 | 600 | 0 | 1000 | 0.00648 |
| 8 | 700 | 0 | 1000 | 0.00648 |
| 9 | 800 | 0 | 1000 | 0.00648 |
| 10 | 0 | 100 | 1000 | 0.00648 |
| 11 | 100 | 100 | 1000 | 0.00648 |
| 12 | 200 | 100 | 1000 | 0.00648 |
| 13 | 300 | 100 | 1000 | 0.00648 |
| 14 | 400 | 100 | 1000 | 0.00648 |
| 15 | 500 | 100 | 1000 | 0.00648 |
| 16 | 600 | 100 | 1000 | 0.00648 |
| 17 | 700 | 100 | 1000 | 0.00648 |
| 18 | 800 | 100 | 1000 | 0.00648 |
| 19 | 0 | 200 | 1000 | 0.00648 |
| 20 | 100 | 200 | 1000 | 0.00648 |
| 21 | 200 | 200 | 1000 | 0.00648 |
| 22 | 300 | 200 | 1000 | 0.00648 |
| 23 | 400 | 200 | 1000 | 0.00648 |
| 24 | 500 | 200 | 1000 | 0.00648 |
| 25 | 600 | 200 | 1000 | 0.00648 |
| 26 | 700 | 200 | 1000 | 0.00648 |
| 27 | 800 | 200 | 1000 | 0.00648 |
| 28 | 0 | 300 | 1000 | 0.00648 |
| 29 | 100 | 300 | 1000 | 0.00648 |
| 30 | 200 | 300 | 1000 | 0.00648 |
| 31 | 300 | 300 | 1000 | 0.00648 |
| 32 | 400 | 300 | 1000 | 0.00648 |
| 33 | 500 | 300 | 1000 | 0.00648 |
| 34 | 600 | 300 | 1000 | 0.00648 |
| 35 | 700 | 300 | 1000 | 0.00648 |
| 36 | 800 | 300 | 1000 | 0.00648 |
| 37 | 0 | 400 | 1000 | 0.00648 |
| 38 | 100 | 400 | 1000 | 0.00648 |
| 39 | 200 | 400 | 1000 | 0.00648 |
| 40 | 300 | 400 | 1000 | 0.00648 |
| 41 | 400 | 400 | 1000 | 0.00648 |
| 42 | 500 | 400 | 1000 | 0.00648 |
| 43 | 600 | 400 | 1000 | 0.00648 |
| 44 | 700 | 400 | 1000 | 0.00648 |
| 45 | 800 | 400 | 1000 | 0.00648 |
| 46 | 0 | 500 | 1000 | 0.00648 |
| 47 | 100 | 500 | 1000 | 0.00648 |
| 48 | 200 | 500 | 1000 | 0.00648 |
| 49 | 300 | 500 | 1000 | 0.00648 |
| 50 | 400 | 500 | 1000 | 0.00648 |
| 51 | 500 | 500 | 1000 | 0.00648 |
| 52 | 600 | 500 | 1000 | 0.00648 |
| 53 | 700 | 500 | 1000 | 0.00648 |
| 54 | 800 | 500 | 1000 | 0.00648 |
| 55 | 0 | 600 | 1000 | 0.00648 |
| 56 | 100 | 600 | 1000 | 0.00648 |
| 57 | 200 | 600 | 1000 | 0.00648 |
| 58 | 300 | 600 | 1000 | 0.00648 |
| 59 | 400 | 600 | 1000 | 0.00648 |
| 60 | 500 | 600 | 1000 | 0.00648 |
| 61 | 600 | 600 | 1000 | 0.00648 |
| 62 | 700 | 600 | 1000 | 0.00648 |
| 63 | 800 | 600 | 1000 | 0.00648 |
| 64 | 0 | 700 | 1000 | 0.00648 |
| 65 | 100 | 700 | 1000 | 0.00648 |
| 66 | 200 | 700 | 1000 | 0.00648 |
| 67 | 300 | 700 | 1000 | 0.00648 |
| 68 | 400 | 700 | 1000 | 0.00648 |
| 69 | 500 | 700 | 1000 | 0.00648 |
| 70 | 600 | 700 | 1000 | 0.00648 |
| 71 | 700 | 700 | 1000 | 0.00648 |
| 72 | 800 | 700 | 1000 | 0.00648 |
| 73 | 0 | 800 | 1000 | 0.00648 |
| 74 | 100 | 800 | 1000 | 0.00648 |
| 75 | 200 | 800 | 1000 | 0.00648 |
| 76 | 300 | 800 | 1000 | 0.00648 |
| 77 | 400 | 800 | 1000 | 0.00648 |
| 78 | 500 | 800 | 1000 | 0.00648 |
| 79 | 600 | 800 | 1000 | 0.00648 |
| 80 | 700 | 800 | 1000 | 0.00648 |
| 81 | 800 | 800 | 1000 | 0.00648 |
| 82 | 900 | 800 | 1001 | - |

* 1. Final design

Table 8. Design of the Moeini & Afahar C1 network*.*

| **ID Pipe** | **Upstream manhole** | **Downstream manhole** | **Upstream invert elevation (m)** | **Downstream invert elevation (m)** | **Length** | **Diameter (m)** | **Slope (-)** | **Type Pipe** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 42 | 43 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 2 | 16 | 25 | 997.3 | 997 | 100.00 | 0.3 | 0.003 | Inner |
| 3 | 43 | 44 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 4 | 65 | 74 | 998.5 | 998.2 | 100.00 | 0.2 | 0.003 | Inner |
| 5 | 13 | 14 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 6 | 34 | 43 | 996.7 | 996.4 | 100.00 | 0.45 | 0.003 | Inner |
| 7 | 49 | 58 | 997.2 | 996.9 | 100.00 | 0.35 | 0.003 | Inner |
| 8 | 53 | 54 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 9 | 73 | 74 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 10 | 80 | 81 | 995.5 | 995.3 | 100.00 | 0.9 | 0.002 | Inner |
| 11 | 58 | 59 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 13 | 12 | 13 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 14 | 60 | 61 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 15 | 59 | 60 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 16 | 44 | 53 | 997.2 | 996.9 | 100.00 | 0.35 | 0.003 | Inner |
| 17 | 4 | 5 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Inner |
| 18 | 40 | 49 | 997.5 | 997.2 | 100.00 | 0.3 | 0.003 | Inner |
| 19 | 33 | 42 | 997.9 | 997.5 | 100.00 | 0.25 | 0.004 | Inner |
| 20 | 79 | 80 | 995.6 | 995.5 | 100.00 | 0.9 | 0.001 | Inner |
| 21 | 33 | 34 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 22 | 72 | 71 | 996.7 | 996.5 | 100.00 | 0.4 | 0.002 | Inner |
| 23 | 47 | 56 | 997.1 | 996.9 | 100.00 | 0.4 | 0.002 | Inner |
| 24 | 67 | 68 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 25 | 44 | 45 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 26 | 64 | 55 | 998.5 | 998.2 | 100.00 | 0.2 | 0.003 | Inner |
| 27 | 8 | 17 | 998.5 | 998.2 | 100.00 | 0.25 | 0.003 | Inner |
| 28 | 29 | 38 | 997.9 | 997.5 | 100.00 | 0.25 | 0.004 | Inner |
| 29 | 37 | 38 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 30 | 7 | 16 | 997.7 | 997.3 | 100.00 | 0.25 | 0.004 | Inner |
| 31 | 39 | 48 | 997.5 | 997.2 | 100.00 | 0.3 | 0.003 | Inner |
| 32 | 4 | 13 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 33 | 64 | 65 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 34 | 3 | 4 | 998.8 | 996.2 | 100.03 | 0.2 | 0.026 | Outer |
| 35 | 60 | 69 | 996.9 | 996.6 | 100.00 | 0.35 | 0.003 | Inner |
| 36 | 40 | 41 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 37 | 72 | 81 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 38 | 5 | 6 | 998.5 | 998.2 | 100.00 | 0.25 | 0.003 | Inner |
| 39 | 21 | 22 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 40 | 48 | 57 | 997.2 | 996.9 | 100.00 | 0.35 | 0.003 | Inner |
| 41 | 56 | 65 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 42 | 12 | 21 | 998.5 | 998.2 | 100.00 | 0.2 | 0.003 | Inner |
| 43 | 55 | 56 | 998.2 | 997.8 | 100.00 | 0.25 | 0.004 | Inner |
| 44 | 75 | 76 | 996.3 | 996.1 | 100.00 | 0.53 | 0.002 | Inner |
| 45 | 22 | 31 | 998.2 | 997.9 | 100.00 | 0.25 | 0.003 | Inner |
| 46 | 31 | 40 | 997.9 | 997.5 | 100.00 | 0.25 | 0.004 | Inner |
| 47 | 65 | 66 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 48 | 52 | 53 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 49 | 9 | 8 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 50 | 35 | 36 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 51 | 10 | 19 | 998.8 | 998.4 | 100.00 | 0.25 | 0.004 | Inner |
| 52 | 24 | 33 | 998.2 | 997.9 | 100.00 | 0.25 | 0.003 | Inner |
| 53 | 14 | 23 | 998.5 | 998.2 | 100.00 | 0.2 | 0.003 | Inner |
| 54 | 52 | 61 | 996.2 | 996 | 100.00 | 0.45 | 0.002 | Inner |
| 55 | 81 | 82 | 995.3 | 995.1 | 100.00 | 0.9 | 0.002 | Inner |
| 56 | 18 | 27 | 998.5 | 998.2 | 100.00 | 0.2 | 0.003 | Inner |
| 57 | 22 | 23 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 58 | 51 | 52 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 59 | 28 | 29 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 60 | 69 | 70 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 61 | 1 | 10 | 998.2 | 996.2 | 100.02 | 0.2 | 0.02 | Inner |
| 62 | 20 | 29 | 998.2 | 997.9 | 100.00 | 0.25 | 0.003 | Inner |
| 63 | 51 | 60 | 997.2 | 996.9 | 100.00 | 0.35 | 0.003 | Inner |
| 64 | 36 | 45 | 997.8 | 997.5 | 100.00 | 0.3 | 0.003 | Inner |
| 65 | 43 | 52 | 996.4 | 996.2 | 100.00 | 0.45 | 0.002 | Inner |
| 66 | 61 | 70 | 996 | 995.8 | 100.00 | 0.45 | 0.002 | Inner |
| 67 | 32 | 41 | 997.9 | 997.5 | 100.00 | 0.25 | 0.004 | Inner |
| 69 | 23 | 24 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 70 | 6 | 7 | 998.2 | 997.7 | 100.00 | 0.25 | 0.005 | Inner |
| 71 | 7 | 8 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 72 | 53 | 62 | 996.9 | 996.6 | 100.00 | 0.35 | 0.003 | Inner |
| 73 | 19 | 28 | 998.4 | 998 | 100.00 | 0.3 | 0.004 | Inner |
| 74 | 9 | 18 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 75 | 71 | 80 | 996.4 | 996.2 | 100.00 | 0.7 | 0.002 | Inner |
| 76 | 76 | 77 | 996.1 | 995.9 | 100.00 | 0.6 | 0.002 | Inner |
| 77 | 3 | 12 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 78 | 66 | 67 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 79 | 15 | 16 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 80 | 31 | 32 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 81 | 37 | 46 | 997.7 | 997.4 | 100.00 | 0.35 | 0.003 | Inner |
| 82 | 6 | 15 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 83 | 74 | 75 | 998.2 | 997.7 | 100.00 | 0.25 | 0.005 | Inner |
| 84 | 3 | 2 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 85 | 39 | 40 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 86 | 47 | 48 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 87 | 10 | 11 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 88 | 21 | 30 | 998.2 | 997.9 | 100.00 | 0.25 | 0.003 | Inner |
| 89 | 46 | 55 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 90 | 56 | 57 | 996.9 | 996.7 | 100.00 | 0.45 | 0.002 | Inner |
| 91 | 11 | 20 | 998.5 | 998.2 | 100.00 | 0.2 | 0.003 | Inner |
| 92 | 24 | 25 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 93 | 67 | 76 | 996.6 | 996.4 | 100.00 | 0.38 | 0.002 | Inner |
| 94 | 70 | 79 | 995.8 | 995.6 | 100.00 | 0.45 | 0.002 | Inner |
| 95 | 78 | 79 | 995.8 | 995.7 | 100.00 | 0.8 | 0.001 | Inner |
| 96 | 17 | 18 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 97 | 38 | 39 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 98 | 26 | 35 | 997.8 | 997.5 | 100.00 | 0.3 | 0.003 | Inner |
| 99 | 32 | 33 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 100 | 77 | 78 | 995.9 | 995.8 | 100.00 | 0.8 | 0.001 | Inner |
| 101 | 57 | 58 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 102 | 68 | 77 | 996.6 | 996.4 | 100.00 | 0.38 | 0.002 | Inner |
| 103 | 42 | 51 | 997.5 | 997.2 | 100.00 | 0.3 | 0.003 | Inner |
| 104 | 27 | 36 | 998.2 | 997.8 | 100.00 | 0.25 | 0.004 | Inner |
| 105 | 16 | 17 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 106 | 15 | 24 | 998.5 | 998.2 | 100.00 | 0.2 | 0.003 | Inner |
| 107 | 25 | 34 | 997 | 996.7 | 100.00 | 0.35 | 0.003 | Inner |
| 108 | 5 | 14 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 109 | 35 | 44 | 997.5 | 997.2 | 100.00 | 0.3 | 0.003 | Inner |
| 110 | 17 | 26 | 998.2 | 997.8 | 100.00 | 0.25 | 0.004 | Inner |
| 111 | 11 | 12 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 112 | 70 | 71 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 113 | 28 | 37 | 998 | 997.7 | 100.00 | 0.3 | 0.003 | Inner |
| 114 | 58 | 67 | 996.9 | 996.6 | 100.00 | 0.35 | 0.003 | Inner |
| 115 | 20 | 21 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 116 | 69 | 78 | 996.6 | 996.4 | 100.00 | 0.38 | 0.002 | Inner |
| 117 | 62 | 71 | 996.6 | 996.4 | 100.00 | 0.5 | 0.002 | Inner |
| 118 | 63 | 72 | 996.9 | 996.7 | 100.00 | 0.35 | 0.002 | Inner |
| 119 | 30 | 39 | 997.9 | 997.5 | 100.00 | 0.25 | 0.004 | Inner |
| 120 | 73 | 64 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 121 | 61 | 62 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 122 | 2 | 11 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 123 | 57 | 66 | 996.7 | 996.5 | 100.00 | 0.5 | 0.002 | Inner |
| 124 | 66 | 75 | 996.5 | 996.3 | 100.00 | 0.5 | 0.002 | Inner |
| 125 | 45 | 54 | 997.5 | 997.2 | 100.00 | 0.35 | 0.003 | Inner |
| 126 | 59 | 68 | 996.9 | 996.6 | 100.00 | 0.35 | 0.003 | Inner |
| 127 | 2 | 1 | 998.5 | 998.2 | 100.00 | 0.2 | 0.003 | Inner |
| 128 | 29 | 30 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 129 | 23 | 32 | 998.2 | 997.9 | 100.00 | 0.25 | 0.003 | Inner |
| 130 | 34 | 35 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 131 | 49 | 50 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 132 | 68 | 69 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 133 | 19 | 20 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 134 | 46 | 47 | 997.4 | 997.1 | 100.00 | 0.35 | 0.003 | Inner |
| 135 | 41 | 50 | 997.5 | 997.2 | 100.00 | 0.3 | 0.003 | Inner |
| 136 | 62 | 63 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 137 | 26 | 27 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 138 | 38 | 47 | 997.5 | 997.2 | 100.00 | 0.3 | 0.003 | Inner |
| 139 | 14 | 15 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 140 | 50 | 51 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 141 | 30 | 31 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 142 | 50 | 59 | 997.2 | 996.9 | 100.00 | 0.35 | 0.003 | Inner |
| 143 | 54 | 63 | 997.2 | 996.9 | 100.00 | 0.35 | 0.003 | Inner |
| 144 | 13 | 22 | 998.5 | 998.2 | 100.00 | 0.2 | 0.003 | Inner |
| 145 | 48 | 49 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 146 | 25 | 26 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |
| 147 | 41 | 42 | 998.8 | 998.5 | 100.00 | 0.2 | 0.003 | Outer |

Table 9. Design of the pumping stations of the Moeini & Afahar C1 network.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Location (manhole)** | **Upstream invert elevation (m)** | **Downstream invert elevation (m)** | **Pumping height (m)** | **Pumping flow rate (m3/s)** |
| 4 | 996.2 | 998.8 | 2.6 | 0.00648 |
| 10 | 996.2 | 998.8 | 2.6 | 0.01944 |

**References**

Duque, N., Duque, D., Aguilar, A., and Saldarriaga, J. (2020). Sewer Network Layout Selection and Hydraulic Design Using a Mathematical Optimization Framework. Water, 12. doi:https://doi.org/10.3390/w12123337

Moeini, R.; Afshar, M.H. (2019) Extension of the hybrid ant colony optimization algorithm for layout and size optimization of sewer networks. Journal of Environmental Informatics, 33, 68–81, https://doi:10.3808/jei.201700369.