# 3 COMPUTERISED HYDRAULIC ANALYSIS

## 3.1 Sprinkler Flow Calculations

NOTES ON WATER VOLUME CALCULATIONS:

- The following table calculates the volume of water used during a full irrigation cycle. This assumes the peak application rate (based on peak EvapoTranspiration).
- This is used in the irrigation design calculations so that the irrigation system can cope with the maximum (peak) demand during the irrigation season.
- In addition to the volumes calculated below, allowance needs to be made for hand and spot watering. This is typically 5 to 15% of the volume required for a full irrigation cycle.
- This is a peak (maximum) daily use calculation during the irrigation season. Actual daily use will vary depending on the weather, particularly rainfall and temperature.
- Annual or monthly water use should be based on actual daily use, not the peak requirements calculated below.
- Depending on site conditions, further allowances may have to be made for evaporation from the lake surface and seepage through the lake floor (water losses).
- There are most likely to be other inflows and outflows from the lake that are not included in these simplistic calculations. Further analysis is not within the scope of the irrigation design.

SPRINKLER FLOW CALCULATIONS

| SPRINKLERS | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Description** | **Unit** | 1 | 2 | 3 | 4 | 5 | 6 |
| Manufacturer | | R' Bird | R' Bird | R' Bird | R' Bird | R' Bird | R' Bird |
| Model | | 900 | 950 | 900 | 950 | 705 | 755 |
| Nozzle | No | 60 | 28 | 48 | 20 | 18 | 18 |
| Colour | | Black | Green | Yellow | Grey | Red | Red |
| Pressure | kPa | 550 | 550 | 550 | 550 | 550 | 550 |
| | PSI | 80 | 80 | 80 | 80 | 80 | 80 |
| Radius | m | 27.7 | 26.2 | 22.8 | 23.2 | 19.8 | 19.8 |
| | ft | 90.9 | 85.9 | 74.8 | 76.1 | 64.9 | 64.9 |
| Flow | L/s | 2.92 | 2.98 | 2.14 | 1.70 | 1.41 | 1.35 |
| | L/min | 175.20 | 178.80 | 128.40 | 102.00 | 84.60 | 81.00 |
| | USGPM | 46.35 | 47.30 | 33.97 | 26.98 | 22.38 | 21.43 |
| Application Rate | mm/hour | 11.68 | 23.84 | 15.44 | 24.54 | 13.29 | 25.45 |
| | in/hour | 0.46 | 0.94 | 0.61 | 0.97 | 0.52 | 1.00 |
| Run Time | min | 30.82 | 15.10 | 23.31 | 14.67 | 27.09 | 14.14 |
| Coverage | % | 54% | 57% | 53% | 52% | 53% | 53% |
| Spacing | m | 30.0 | 30.0 | 24.0 | 24.0 | 21.0 | 21.0 |
| | ft | 98.4 | 98.4 | 78.7 | 78.7 | 68.9 | 68.9 |
| Pattern | Tri/Sq/Si | Square | Square | Triangle | Triangle | Triangle | Triangle |
| Arc | degrees | 360 | 180 | 360 | 180 | 360 | 180 |
| Peak Application | mm/day | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| | mm/week | 42.00 | 42.00 | 42.00 | 42.00 | 42.00 | 42.00 |
| | in/day | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| | in/week | 1.65 | 1.65 | 1.65 | 1.65 | 1.65 | 1.65 |
| Number of Sprinklers** | No | 6 | 0 | 141 | 15 | 2,027 | 181 |
| Total No Sprinklers** | No | 2,370 | | | | | |
| Water Used per Irrigation Cycle | cu. m | 32 | 0 | 422 | 22 | 4,645 | 208 |
| | US Gal. | 8,571 | 0 | 111,640 | 5,839 | 1,228,767 | 54,937 |
| Total Water Used per Irrigation Cycle | cu. m | 5,329 | | | | | |
| | US Gal. | 1,409,755 | | | | | |

** These are Equivalent Sprinklers (for equivalent application)
and may not correlate exactly with actual numbers.

3.2 Irrigation Pump Station Flow Calculations

| PUMP STATION FLOWS | | |
|---|---|---|
| **Description** | **Unit** | |
| Water Used per Irrigation Cycle | cu. m | 5,329 |
| | US Gal. | 1,409,755 |
| Watering Window | Hours | 8.00 |
| Scheduling Efficiency of Central Controller | % | 93% |
| **Total Pump Station Flow** | L/s | 200.00 |
| | USGPM | 3,175 |
| Number of Sprinklers running Simultaneously (Type 5 Sprinklers) | No | 142 |
| **Total Dynamic Head** | m | 111.5 |
| | PSI | 158.8 |
| Pump Efficiency | % | 80% |
| Service Factor | % | 15% |
| Number of Duty Pumps | No | 6 |
| Motor Output Rating (Each Motor) | kW | 52 |
| | Hp | 70 |
| Motor Efficiency | % | 90% |
| Estimated Total Input Power for Main Pump Electric Motors | kW | 349 |
| | Hp | 468 |
| Peak Power Demand | kW | 407 |
| | Hp | 546 |
| **INTAKE LINE (from Lake to Wet Well)** | | |
| Diameter (Internal) | mm | 750 |
| | Inches | 30 |
| Fluid Velocity | m/s | 0.45 |
| | ft/s | 1.48 |
| **DISCHARGE LINE (from Pump to field)** | | |
| Diameter (Internal) Schedule 40 Steel | mm | 350 |
| | Inches | 14 |
| Fluid Velocity | m/s | 2.08 |
| | ft/s | 6.82 |
| **ESTIMATED ANNUAL ELECTRICITY COST** | | |
| Volume | m^3/yr | 764,764 |
| Run Time at Full flow | Hr/Yr | 1,062 |
| | Hr/Day | 2.91 |
| Cost of Electricity | US$/kW.Hr | 0.12 |
| | US$/Year | 44,505 |

3.3 Drawdown on Irrigation Lake

| IRRIGATION LAKE DAILY DRAWDOWN | | |
|---|---|---|
| **Peak Daily Water Demand Estimates** | | |
| Full Irrigation Cycle | m^3 | 5,329 |
| | US Gallons | 1,409,755 |
| Hand Watering | % | 10% |
| | m^3 | 533 |
| | US Gallons | 140,975 |
| Lake Surface Evaporation | mm/day | 4.00 |
| | inches/day | 0.16 |
| | m^3/day | 39 |
| | US Gallons | 10,206 |
| Lake Floor Seepage | mm/day | 2.00 |
| | inches/day | 0.08 |
| | m^3/day | 19 |
| | US Gallons | 5,103 |
| Total Peak Water Demand | m^3/day | 5,920 |
| | US Gallons | 1,566,039 |
| **Storage Estimates** | | |
| Lake Surface Area (When Full) | Ha | 0.96 |
| | m^2 | 9,645 |
| | Acre | 2.38 |
| Depth Useable for Irrigation | m | 2.00 |
| | ft | 6.56 |
| Perimeter | m | 438 |
| | ft | 1,438 |
| Lake Edge Slope (v:h) | 1: | 3.00 |
| Volume when full | m^3 | 16,735 |
| | US Gallons | 4,427,263 |
| Daily Drawdown (When Lake is Full) | mm/day | 614 |
| | inches/day | 24 |
| Storage at Full Use for Dry Period (Approximate) | Days | 3 |

**IMPORTANT NOTE:**

The above estimates will vary with this particular site. Factors that will change these calculations include (but are not limited to): Water management decisions and practices by staff; climate influence on evaporation; soil structure or lake lining used; and actual constructed dimensions of the lake.

However, it is important to note that there is only 3 days of water storage in the irrigation lake (at full use). This fact stresses the need for a reliable water source (the river) and transfer pumps.

3.4 Irrigation Pump Station Head Summary

| IRRIGATION PUMP STATION HEAD SUMMARY | | | | |
|---|---|---|---|---|
| Description | Metres | kPa | Feet | PSI |
| **Elevations** | | | | |
| Highest Elevation Serviced by Pump | 81.0 | | 266 | |
| Elevation at the Most Critical Point | 80.0 | | 262 | |
| Lowest Elevation Serviced by Pump | 53.0 | | 174 | |
| Elevation Variation Serviced by Pump | 28.0 | | 92 | |
| Discharge Head | 54.0 | | 177 | |
| Pump Station Pad | 53.5 | | 175 | |
| Maximum Irrigation Lake Water Level | 52.5 | | 172 | |
| Minimum Irrigation Lake Water Level | 44.5 | | 146 | |
| Bottom of Irrigation Lake | 44.0 | | 144 | |
| **Pressure Loss Summary (At Most Critical Point)** | | | | |
| Filter Losses | 3.1 | 30 | 10 | 4 |
| Elevation Head Above Discharge Head | 26.0 | 255 | 85 | 37 |
| Mainline Losses | 7.7 | 76 | 25 | 11 |
| Lateral Line Losses | 4.0 | 39 | 13 | 6 |
| Sprinkler Operating Pressure | 56.1 | 550 | 184 | 80 |
| Safety Margin | 5.1 | 50 | 17 | 7 |
| Pressure at Discharge Head | 102.0 | 1,000 | 334 | 145 |
| Add: Water Lift to Discharge Head | 9.5 | 93 | 31 | 14 |
| **TOTAL DYNAMIC HEAD** | 111.5 | 1,093 | 366 | 159 |
| Unregulated Static Head | 111.0 | 1,088 | 364 | 158 |
| % of Working Pressure - Class D Pipe | | 91% | | |
| % of Working Pressure - Class 200 Pipe | | | | 79% |
| Regulated Static Head | 103.0 | 1,010 | 338 | 147 |
| % of Working Pressure - Class D Pipe | | 84% | | |
| % of Working Pressure - Class 200 Pipe | | | | 73% |

**IMPORTANT NOTES** on the Most Critical Point:

3.4.1 The Most Critical Point depends on a combination of:

- ♦ Distance from the Irrigation Pump Station
- ♦ Elevation above the Irrigation Pump Station
- ♦ Operating pressure of the sprinklers
- ♦ Lateral losses

3.4.2 Typically this is the point at the highest elevation furthermost from the Irrigation Pump Station. However, if the furthermost point is at a low elevation, then a point closer to the Pump Station but at a higher elevation may be the most critical point.

3.4.3 On a golf course, a tee box is often the highest point but frequently these sprinklers are running at a lower pressure and therefore they may not be the most critical points.

3.4.4 At higher elevations on hilly sites, the lateral lines are often not as long and therefore the lateral line losses may be less than longer laterals at lower, flatter areas of the course.

**IMPORTANT NOTES** on the Static Head

3.4.5 Aside from pressure surges (a feature of dynamic flows and not static situations), ***the highest pressure in the system will occur at the lowest elevation when there is no flow*** (and consequently no loss of pressure from friction losses). This ***is termed the "Static Head"***. It is why pipes and fitting failures typically occur at the lowest elevations in a hydraulic zone.

3.4.6 Our system is designed to operate with the calculated pressure at the Discharge Head. However, the pump calculations require a Total Dynamic Head which is from the lowest water level (worst case scenario).

3.4.7 Without the regulation of the Programmable Logic Controller and Variable Frequency Drives (as would be the case when over-riding the Pump Control System in manual operation), the pressure at the discharge head could rise above the design discharge pressure when the irrigation lake is at its highest level.

This is used to calculate our "Unregulated Static Head" which would only occur during manual over-ride situations. This will not occur during normal operation of the system.

3.4.8 With the pressure regulation of the Programmable Logic Controller and Variable Frequency Drives, the design discharge pressure is maintained regardless of the water level in the irrigation lake (typically with in say 25 kPa or 4 PSI).

This design discharge pressure is used to calculate the "Regulated Static Head". This would be present (at the lowest elevation) during normal operation of the system at zero flow.

3.5 Booster Pump Station No 1 Head Summary

| **BOOSTER PUMP STATION No 1 - HEAD SUMMARY** | | | | |
|---|---|---|---|---|
| Description | Metres | kPa | Feet | PSI |
| **Elevations** | | | | |
| Highest Elevation Serviced by Pump | 102.0 | | 335 | |
| Elevation at the Most Critical Point | 102.0 | | 335 | |
| Lowest Elevation Serviced by Pump | 55.0 | | 180 | |
| Elevation Variation Serviced by Pump | 47.0 | | 154 | |
| Pump Station Pad | 80.0 | | 262 | |
| **Pressure at Intake** | | | | |
| Unregulated Static Pressure at Intake | 84.0 | 823 | 275 | 120 |
| Regulated Static Pressure at Intake | 76.0 | 745 | 249 | 108 |
| Mainline Losses From IPS to BPS | 5.6 | 55 | 18 | 8 |
| Dynamic Pressure at Intake | 70.4 | 690 | 231 | 100 |
| **Pressure Loss Summary (At Most Critical Point)** | | | | |
| Elevation Head Above Pump Pad | 22.0 | 216 | 72 | 31 |
| Mainline Losses | 5.7 | 56 | 19 | 8 |
| Lateral Line Losses | 6.7 | 66 | 22 | 10 |
| Sprinkler Operating Pressure | 56.1 | 550 | 184 | 80 |
| Safety Margin | 2.5 | 25 | 8 | 4 |
| Dynamic Pressure at Discharge | 93.1 | 913 | 305 | 133 |
| Less: Dynamic Pressure at Intake | 70.4 | 690 | 231 | 100 |
| **TOTAL DYNAMIC HEAD** | 22.7 | 223 | 74 | 32 |
| Unregulated Static Head | 131.7 | 1,291 | 432 | 188 |
| % of Working Pressure - Class F | | 72% | | |
| % of Working Pressure - PN 16 | | 81% | | |
| % of Working Pressure - Class 315 | | | | 60% |
| Regulated Static Head | 123.7 | 1,213 | 406 | 176 |
| % of Working Pressure - Class F | | 67% | | |
| % of Working Pressure - PN 16 | | 76% | | |
| % of Working Pressure - Class 315 | | | | 56% |

| **POWER CALCULATIONS** | | |
|---|---|---|
| Flow | L/s | 27 |
| | USGPM | 429 |
| Pump Efficiency | % | 60% |
| Service Factor | % | 15% |
| Estimated Power for Electric Motor | kW | 13 |
| (only 1 pump) | Hp | 17 |
| Peak Power Demand | kW | 26 |
| | Hp | 34 |

3.6 Booster Pump Station No 1 Head Summary

| BOOSTER PUMP STATION No 2 - HEAD SUMMARY | | | | |
|---|---|---|---|---|
| Description | Metres | kPa | Feet | PSI |
| **Elevations** | | | | |
| Highest Elevation Serviced by Pump | 100.0 | | 328 | |
| Elevation at the Most Critical Point | 100.0 | | 328 | |
| Lowest Elevation Serviced by Pump | 80.0 | | 262 | |
| Elevation Variation Serviced by Pump | 20.0 | | 66 | |
| Pump Station Pad | 80.0 | | 262 | |
| **Pressure at Intake** | | | | |
| Unregulated Static Pressure at Intake | 84.0 | 823 | 275 | 120 |
| Regulated Static Pressure at Intake | 76.0 | 745 | 249 | 108 |
| Mainline Losses From IPS to BPS | 3.8 | 37 | 12 | 5 |
| Dynamic Pressure at Intake | 72.2 | 708 | 237 | 103 |
| **Pressure Loss Summary (At Most Critical Point)** | | | | |
| Elevation Head Above Pump Pad | 20.0 | 196 | 66 | 28 |
| Mainline Losses | 5.7 | 56 | 19 | 8 |
| Lateral Line Losses | 3.6 | 35 | 12 | 5 |
| Sprinkler Operating Pressure | 56.1 | 550 | 184 | 80 |
| Safety Margin | 9.5 | 93 | 31 | 14 |
| Dynamic Pressure at Discharge | 94.8 | 930 | 311 | 135 |
| Less: Dynamic Pressure at Intake | 72.2 | 708 | 237 | 103 |
| **TOTAL DYNAMIC HEAD** | 22.7 | 222 | 74 | 32 |
| Unregulated Static Head | 106.6 | 1,046 | 350 | 152 |
| % of Working Pressure - Class D | | 87% | | |
| % of Working Pressure - PN 12 | | 87% | | |
| % of Working Pressure - Class 200 | | | | 76% |
| Regulated Static Head | 98.6 | 967 | 324 | 140 |
| % of Working Pressure - Class D | | 81% | | |
| % of Working Pressure - PN 12 | | 81% | | |
| % of Working Pressure - Class 200 | | | | 70% |

| POWER CALCULATIONS | | |
|---|---|---|
| Flow | L/s | 27 |
| | USGPM | 429 |
| Pump Efficiency | % | 60% |
| Service Factor | % | 15% |
| Estimated Power for Electric Motor | kW | 13 |
| (only 1 pump) | Hp | 17 |
| Peak Power Demand | kW | 26 |
| | Hp | 34 |

It is noted that the safety margin for this pump is 93 kPa (compared to 25 kPa for Booster Pump Station No 1). This is so that both booster pump station have identical duty (flow and pressure). This will reduce up-front costs as well as improving maintenance and backup.

3.7 Pressure Loss Summary (Dynamic)

| **PRESSURE LOSS SUMMARY (Dynamic) for Critical Points** | | | | |
|---|---|---|---|---|
| Description | kPa | Metres | Feet | PSI |
| ***Irrigation Pump Station*** | | | | |
| **Straight Line Fairway Lateral**<br>**Node 26 On Hole 3** | | | | |
| Minimum Mainline Pressure for above sprinklers (as per computerised hydraulic analysis) | 674 | 68.7 | 225 | 98 |
| Less: Filter Losses (as per specifications) | 30 | 3.1 | 10 | 4 |
| Less: Lateral Line Losses (as calculated later) | 44 | 4.5 | 15 | 6 |
| Less: Sprinkler Operating Pressure (as per specifications) | 550 | 56.1 | 184 | 80 |
| Safety Margin | 50 | 5.1 | 17 | 7 |
| ***Booster Pump Station No 1*** | | | | |
| **Green Lateral**<br>**Node 38 On Hole 15** | | | | |
| Minimum Mainline Pressure for above sprinklers (as per computerised hydraulic analysis) | 671 | 68.4 | 224 | 97 |
| Less: Filter Losses (as per specifications) | 30 | 3.1 | 10 | 4 |
| Less: Lateral Line Losses (as calculated later) | 66 | 6.7 | 22 | 10 |
| Less: Sprinkler Operating Pressure (as per specifications) | 550 | 56.1 | 184 | 80 |
| Safety Margin | 25 | 2.5 | 8 | 4 |
| ***Booster Pump Station No 2*** | | | | |
| **H-Pattern Fairway Lateral**<br>**Node 46 On Hole 5** | | | | |
| Minimum Mainline Pressure for above sprinklers (as per computerised hydraulic analysis) | 708 | 72.2 | 237 | 103 |
| Less: Filter Losses (as per specifications) | 30 | 3.1 | 10 | 4 |
| Less: Lateral Line Losses (as calculated later) | 35 | 3.6 | 12 | 5 |
| Less: Sprinkler Operating Pressure (as per specifications) | 550 | 56.1 | 184 | 80 |
| Safety Margin | 93 | 9.5 | 31 | 13 |

The above table summarises the computerised hydraulic analysis at the critical points and demonstrates that there is sufficient pressure at these critical points as well as some wear and tear on the pumps.

## 3.8 Sample Run of a Typical Irrigation Cycle (Dynamic)

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  FLOWS ARE EXPRESSED IN LITERS PER SECOND AND PRESSURES IN KPA
A SUMMARY OF THE ORIGINAL DATA FOLLOWS
   PIPE NO. NODE NOS. LENGTH  DIAMETER  ROUGHNESS  MINOR LOSS K   FIXED GRADE
                     (METERS)   (CMS)
     1       0    1       13.0    35.0      150.0         .00         44.50
LINE    1 PUMP DATA (HEAD-FLOW):   120.0       .0   111.5   200.0    70.0   300.0
     2       1    2       20.0    30.0      150.0         .00
     3       2    3      401.0    30.0      150.0         .00
     4       3    4      140.0    30.0      150.0         .00
     5       4    5       54.0    25.0      150.0         .00
     6       5    6       95.0    20.0      150.0         .00
     7       6    7      515.0    15.0      150.0         .00
     8       7    8      306.0    15.0      150.0         .00
     9       6    9      610.0    20.0      150.0         .00
    10       1   10      130.0    30.0      150.0         .00
    11      10   11      178.0    30.0      150.0         .00
    12      10   12      542.0    30.0      150.0         .00
    13      12   13      120.0    30.0      150.0         .00
    14      13   14      308.0    15.0      150.0         .00
    15      14   15      270.0    15.0      150.0         .00
    16      15   16       10.0    20.0      150.0         .00
    17      16   17       86.0    20.0      150.0         .00
    18      17   18      308.0    20.0      150.0         .00
    19      18   19      420.0    30.0      150.0         .00
    20      19   20      274.0    30.0      150.0         .00
    21      20   21      380.0    25.0      150.0         .00
    22      21   22      195.0    25.0      150.0         .00
    23      22   23      180.0    20.0      150.0         .00
    24      13   24      260.0    20.0      150.0         .00
    25      24   25      702.0    20.0      150.0         .00
    26      25   26      367.0    20.0      150.0         .00
    27      26   27      471.0    20.0      150.0         .00
    28      27   28       20.0    20.0      150.0         .00
    29      28   29      520.0    10.0      150.0         .00
    30      28   30      502.0    20.0      150.0         .00
    31      31   32      605.0    15.0      150.0         .00
    32      31   32      745.0    15.0      150.0         .00
    33      30   33      275.0    20.0      150.0         .00
    34      33   34       83.0    15.0      150.0         .00
    35      34   35       10.0    15.0      150.0         .00
LINE   35 PUMP DATA (HEAD-FLOW):   150.0       .0    22.8    27.5    10.0    40.0
    36      35   36       20.0    15.0      150.0         .00
    37      36   37      511.0    15.0      150.0         .00
    38      37   38      210.0    10.0      150.0         .00
    39      37   39      330.0    15.0      150.0         .00
    40      36   40      500.0    15.0      150.0         .00
    41      40   41      150.0    10.0      150.0         .00
    42      40   42      620.0    10.0      150.0         .00
    43      23   27      446.0    20.0      150.0         .00
    44      18   23      290.0    20.0      150.0         .00
    45       2   19      176.0    30.0      150.0         .00
    46       4   11      512.0    30.0      150.0         .00
    47       5    8      568.0    15.0      150.0         .00
    48       9   12      623.0    25.0      150.0         .00
    49      15   43       10.0    15.0      150.0         .00
    50      43   44       10.0    15.0      150.0         .00
LINE   50 PUMP DATA (HEAD-FLOW):    50.0       .0    22.8    27.5    10.0    40.0
    51       3   20      200.0    15.0      150.0         .00
    52       7    9       46.0    15.0      150.0         .00
    53      22   30      120.0    25.0      150.0         .00
    54      44   46      333.0    10.0      150.0         .00
    55      46   47      155.0    10.0      150.0         .00
    56      45   46      278.0    10.0      150.0         .00
    57      44   45       84.0    15.0      150.0         .00
    58      21   32       96.0    15.0      150.0         .00
```

A SUCCESSFUL GEOMETRIC VERIFICATION HAS BEEN COMPLETED

| JUNCTION NUMBER | DEMAND | ELEVATION | CONNECTING PIPES | | |
|---|---|---|---|---|---|
| 1 | .00 | 55.00 | 1 | 2 | 10 |
| 2 | .00 | 56.00 | 2 | 3 | 45 |
| 3 | .00 | 60.00 | 3 | 4 | 51 |
| 4 | .00 | 57.00 | 4 | 5 | 46 |
| 5 | 5.00 | 54.00 | 5 | 6 | 47 |
| 6 | .00 | 57.00 | 6 | 7 | 9 |
| 7 | 10.00 | 74.00 | 7 | 8 | 52 |
| 8 | 10.00 | 76.00 | 8 | 47 | |
| 9 | .00 | 59.00 | 9 | 48 | 52 |
| 10 | .00 | 58.00 | 10 | 11 | 12 |
| 11 | .00 | 58.00 | 11 | 46 | |
| 12 | 5.00 | 59.00 | 12 | 13 | 48 |
| 13 | 5.00 | 62.00 | 13 | 14 | 24 |
| 14 | 10.00 | 63.00 | 14 | 15 | |
| 15 | 10.00 | 56.00 | 15 | 16 | 49 |
| 16 | .00 | 56.00 | 16 | 17 | |
| 17 | .00 | 90.00 | 17 | 18 | |
| 18 | 10.00 | 81.00 | 18 | 19 | 44 |
| 19 | .00 | 56.00 | 19 | 20 | 45 |
| 20 | 5.00 | 58.00 | 20 | 21 | 51 |
| 21 | 10.00 | 57.00 | 21 | 22 | 58 |
| 22 | .00 | 59.00 | 22 | 23 | 53 |
| 23 | .00 | 57.00 | 23 | 43 | 44 |
| 24 | 10.00 | 69.00 | 24 | 25 | |
| 25 | .00 | 77.00 | 25 | 26 | |
| 26 | 10.00 | 84.00 | 26 | 27 | |
| 27 | 10.00 | 72.00 | 27 | 28 | 43 |
| 28 | 10.00 | 72.00 | 28 | 29 | 30 |
| 29 | 5.00 | 80.00 | 29 | | |
| 30 | .00 | 59.00 | 30 | 33 | 53 |
| 31 | 10.00 | 57.00 | 31 | 32 | |
| 32 | 5.00 | 60.00 | 31 | 32 | 58 |
| 33 | 5.00 | 54.00 | 33 | 34 | |
| 34 | .00 | 80.00 | 34 | 35 | |
| 35 | .00 | 80.00 | 35 | 36 | |
| 36 | .00 | 80.00 | 36 | 37 | 40 |
| 37 | 2.50 | 95.00 | 37 | 38 | 39 |
| 38 | 5.00 | 102.00 | 38 | | |
| 39 | 5.00 | 101.00 | 39 | | |
| 40 | 5.00 | 101.00 | 40 | 41 | 42 |
| 41 | 5.00 | 100.00 | 41 | | |
| 42 | 5.00 | 90.00 | 42 | | |
| 43 | .00 | 80.00 | 49 | 50 | |
| 44 | 10.00 | 80.00 | 50 | 54 | 57 |
| 45 | 2.50 | 92.00 | 56 | 57 | |
| 46 | 10.00 | 100.00 | 54 | 55 | 56 |
| 47 | 5.00 | 98.00 | 55 | | |

OUTPUT SELECTION: ALL RESULTS ARE OUTPUT EACH PERIOD
THIS SYSTEM HAS 58 PIPES WITH 47 JUNCTIONS , 11 LOOPS AND 1 FGNS

THE RESULTS ARE OBTAINED AFTER 6 TRIALS WITH AN ACCURACY = .00032
CHUNG HUA HOT SPRINGS GOLF COURSE

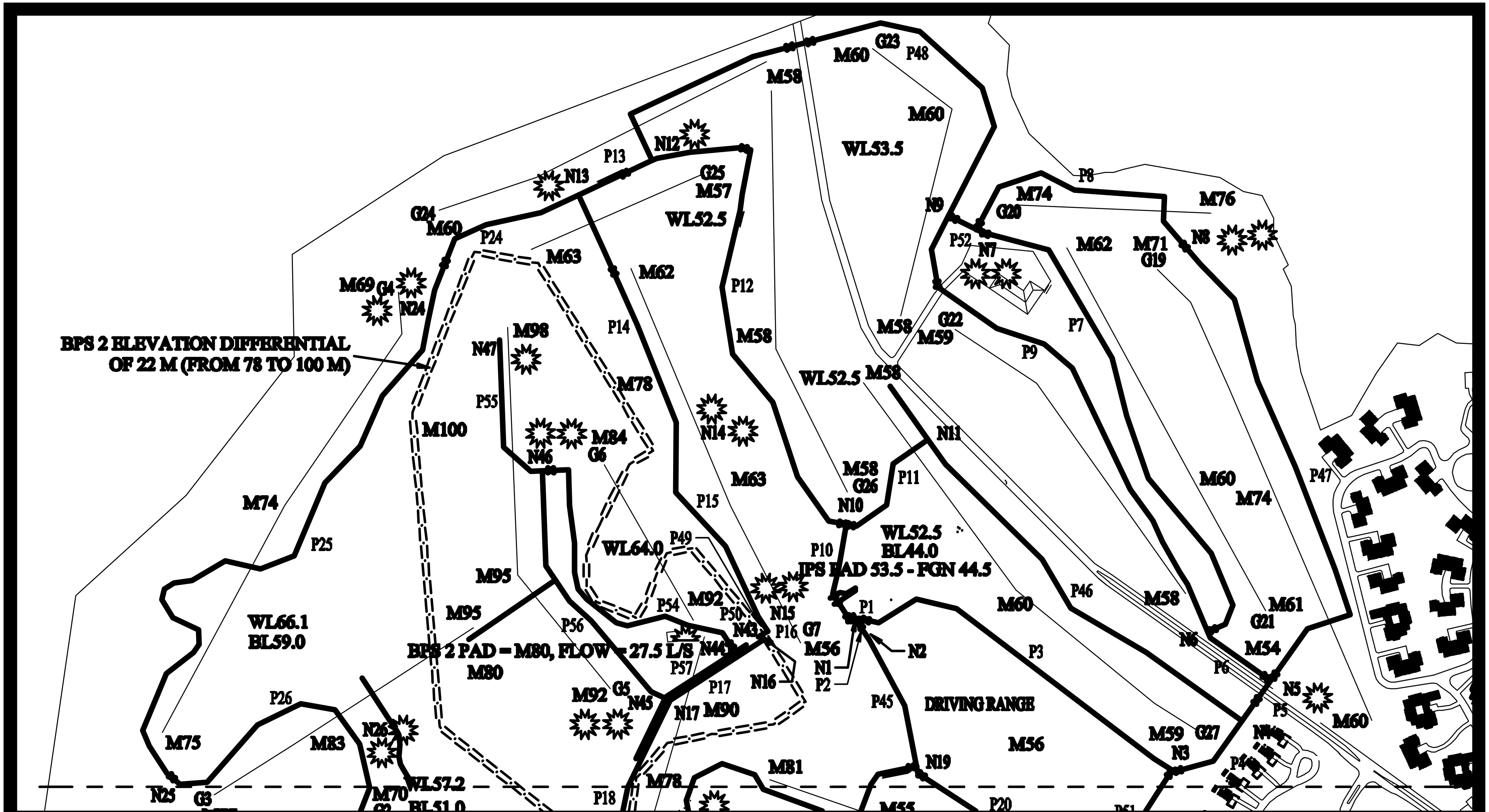
| PIPE NO. | NODE NOS. | | FLOWRATE | HEAD LOSS | PUMP HEAD | MINOR LOSS | VELOCITY | HL/1000 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 1 | 200.00 | .11 | 111.49 | .00 | 2.08 | 8.41 |
| 2 | 1 | 2 | 134.80 | .17 | .00 | .00 | 1.91 | 8.58 |
| 3 | 2 | 3 | 30.03 | .21 | .00 | .00 | .42 | .53 |
| 4 | 3 | 4 | 13.85 | .02 | .00 | .00 | .20 | .13 |
| 5 | 4 | 5 | 29.67 | .07 | .00 | .00 | .60 | 1.26 |
| 6 | 5 | 6 | 17.51 | .13 | .00 | .00 | .56 | 1.41 |
| 7 | 6 | 7 | 6.18 | .43 | .00 | .00 | .35 | .83 |
| 8 | 7 | 8 | 2.83 | .06 | .00 | .00 | .16 | .20 |
| 9 | 6 | 9 | 11.33 | .38 | .00 | .00 | .36 | .63 |
| 10 | 1 | 10 | 65.20 | .29 | .00 | .00 | .92 | 2.24 |
| 11 | 10 | 11 | 15.82 | .03 | .00 | .00 | .22 | .16 |
| 12 | 10 | 12 | 49.38 | .72 | .00 | .00 | .70 | 1.34 |
| 13 | 12 | 13 | 49.06 | .16 | .00 | .00 | .69 | 1.32 |
| 14 | 13 | 14 | 18.36 | 1.93 | .00 | .00 | 1.04 | 6.25 |
| 15 | 14 | 15 | 8.36 | .39 | .00 | .00 | .47 | 1.46 |
| 16 | 15 | 16 | -29.14 | -.04 | .00 | .00 | -.93 | -3.62 |
| 17 | 16 | 17 | -29.14 | -.31 | .00 | .00 | -.93 | -3.62 |
| 18 | 17 | 18 | -29.14 | -1.12 | .00 | .00 | -.93 | -3.62 |
| 19 | 18 | 19 | -64.13 | -.91 | .00 | .00 | -.91 | -2.17 |
| 20 | 19 | 20 | 40.64 | .26 | .00 | .00 | .57 | .93 |
| 21 | 20 | 21 | 51.82 | 1.35 | .00 | .00 | 1.06 | 3.55 |
| 22 | 21 | 22 | 26.82 | .20 | .00 | .00 | .55 | 1.05 |
| 23 | 22 | 23 | -11.01 | -.11 | .00 | .00 | -.35 | -.60 |
| 24 | 13 | 24 | 25.69 | .75 | .00 | .00 | .82 | 2.87 |
| 25 | 24 | 25 | 15.69 | .81 | .00 | .00 | .50 | 1.15 |
| 26 | 25 | 26 | 15.69 | .42 | .00 | .00 | .50 | 1.15 |
| 27 | 26 | 27 | 5.69 | .08 | .00 | .00 | .18 | .18 |
| 28 | 27 | 28 | 9.67 | .01 | .00 | .00 | .31 | .47 |
| 29 | 28 | 29 | 5.00 | 2.11 | .00 | .00 | .64 | 4.05 |
| 30 | 28 | 30 | -5.33 | -.08 | .00 | .00 | -.17 | -.16 |
| 31 | 31 | 32 | -5.28 | -.38 | .00 | .00 | -.30 | -.62 |
| 32 | 31 | 32 | -4.72 | -.38 | .00 | .00 | -.27 | -.51 |
| 33 | 30 | 33 | 32.50 | 1.22 | .00 | .00 | 1.03 | 4.43 |
| 34 | 33 | 34 | 27.50 | 1.10 | .00 | .00 | 1.56 | 13.21 |
| 35 | 34 | 35 | 27.50 | .13 | 22.84 | .00 | 1.56 | 13.21 |
| 36 | 35 | 36 | 27.50 | .26 | .00 | .00 | 1.56 | 13.21 |
| 37 | 36 | 37 | 12.50 | 1.57 | .00 | .00 | .71 | 3.07 |
| 38 | 37 | 38 | 5.00 | .85 | .00 | .00 | .64 | 4.05 |
| 39 | 37 | 39 | 5.00 | .19 | .00 | .00 | .28 | .56 |
| 40 | 36 | 40 | 15.00 | 2.15 | .00 | .00 | .85 | 4.30 |
| 41 | 40 | 41 | 5.00 | .61 | .00 | .00 | .64 | 4.05 |
| 42 | 40 | 42 | 5.00 | 2.51 | .00 | .00 | .64 | 4.05 |
| 43 | 23 | 27 | 13.97 | .41 | .00 | .00 | .44 | .93 |
| 44 | 18 | 23 | 24.99 | .79 | .00 | .00 | .80 | 2.73 |
| 45 | 2 | 19 | 104.77 | .95 | .00 | .00 | 1.48 | 5.38 |
| 46 | 4 | 11 | -15.82 | -.08 | .00 | .00 | -.22 | -.16 |
| 47 | 5 | 8 | 7.17 | .62 | .00 | .00 | .41 | 1.10 |
| 48 | 9 | 12 | 4.67 | .03 | .00 | .00 | .10 | .04 |
| 49 | 15 | 43 | 27.50 | .13 | .00 | .00 | 1.56 | 13.21 |
| 50 | 43 | 44 | 27.50 | .13 | 22.84 | .00 | 1.56 | 13.21 |
| 51 | 3 | 20 | 16.18 | .99 | .00 | .00 | .92 | 4.94 |
| 52 | 7 | 9 | -6.66 | -.04 | .00 | .00 | -.38 | -.95 |
| 53 | 22 | 30 | 37.83 | .24 | .00 | .00 | .77 | 1.98 |
| 54 | 44 | 46 | 7.27 | 2.70 | .00 | .00 | .93 | 8.10 |
| 55 | 46 | 47 | 5.00 | .63 | .00 | .00 | .64 | 4.05 |
| 56 | 45 | 46 | 7.73 | 2.52 | .00 | .00 | .98 | 9.07 |
| 57 | 44 | 45 | 10.23 | .18 | .00 | .00 | .58 | 2.12 |
| 58 | 21 | 32 | 15.00 | .41 | .00 | .00 | .85 | 4.30 |

| JUNCTION NUMBER | DEMAND | GRADE LINE | ELEVATION | PRESSURE | |
|---|---|---|---|---|---|
| **Irrigation Pump Station Hydraulic Zone** | | | | | |
| 1 | .00 | 155.88 | 55.00 | 989.31 | |
| 2 | .00 | 155.71 | 56.00 | 977.82 | |
| 3 | .00 | 155.50 | 60.00 | 936.50 | |
| 4 | .00 | 155.48 | 57.00 | 965.75 | |
| 5 | 5.00 | 155.41 | 54.00 | 994.50 | |
| 6 | .00 | 155.28 | 57.00 | 963.76 | |
| 7 | 10.00 | 154.85 | 74.00 | 792.85 | |
| 8 | 10.00 | 154.79 | 76.00 | 772.65 | |
| 9 | .00 | 154.89 | 59.00 | 940.38 | |
| 10 | .00 | 155.59 | 58.00 | 957.04 | |
| 11 | .00 | 155.56 | 58.00 | 956.75 | |
| 12 | 5.00 | 154.87 | 59.00 | 940.13 | |
| 13 | 5.00 | 154.71 | 62.00 | 909.16 | |
| 14 | 10.00 | 152.78 | 63.00 | 880.46 | |
| 15 | 10.00 | 152.39 | 56.00 | 945.25 | |
| 16 | .00 | 152.42 | 56.00 | 945.61 | |
| 17 | .00 | 152.74 | 90.00 | 615.24 | (No Sprinklers) |
| 18 | 10.00 | 153.85 | 81.00 | 714.44 | |
| 19 | .00 | 154.76 | 56.00 | 968.53 | |
| 20 | 5.00 | 154.51 | 58.00 | 946.42 | |
| 21 | 10.00 | 153.16 | 57.00 | 943.00 | |
| 22 | .00 | 152.95 | 59.00 | 921.38 | |
| 23 | .00 | 153.06 | 57.00 | 942.05 | |
| 24 | 10.00 | 153.96 | 69.00 | 833.19 | |
| 25 | .00 | 153.15 | 77.00 | 746.81 | |
| 26 | 10.00 | 152.73 | 84.00 | 674.02 | (Critical Point) |
| 27 | 10.00 | 152.65 | 72.00 | 790.88 | |
| 28 | 10.00 | 152.64 | 72.00 | 790.79 | |
| 29 | 5.00 | 150.53 | 80.00 | 691.69 | |
| 30 | .00 | 152.72 | 59.00 | 919.05 | |
| 31 | 10.00 | 152.37 | 57.00 | 935.26 | |
| 32 | 5.00 | 152.75 | 60.00 | 909.53 | |
| 33 | 5.00 | 151.50 | 54.00 | 956.12 | |
| **Booster Pump Station No 1 Hydraulic Zone** | | | | | |
| 34 | .00 | 150.40 | 80.00 | 690.39 | (Intake Point) |
| 35 | .00 | 173.11 | 80.00 | 913.08 | (Discharge Point) |
| 36 | .00 | 172.84 | 80.00 | 910.49 | |
| 37 | 2.50 | 171.28 | 95.00 | 748.02 | |
| 38 | 5.00 | 170.43 | 102.00 | 671.04 | (Critical Point) |
| 39 | 5.00 | 171.09 | 101.00 | 687.36 | |
| 40 | 5.00 | 170.69 | 101.00 | 683.47 | |
| 41 | 5.00 | 170.09 | 100.00 | 687.32 | |
| 42 | 5.00 | 168.18 | 90.00 | 766.73 | |
| **Booster Pump Station No 2 Hydraulic Zone** | | | | | |
| 43 | .00 | 152.26 | 80.00 | 708.60 | (Intake Point) |
| 44 | 10.00 | 174.96 | 80.00 | 931.29 | (Discharge Point) |
| 45 | 2.50 | 174.79 | 92.00 | 811.86 | |
| 46 | 10.00 | 172.27 | 100.00 | 708.69 | (Critical Point) |
| 47 | 5.00 | 171.64 | 98.00 | 722.15 | |

THE NET SYSTEM DEMAND = 200.00
SUMMARY OF INFLOWS(+) AND OUTFLOWS(-) FROM FIXED GRADE NODES

| PIPE NUMBER | FLOWRATE |
|---|---|
| 1 | 200.00 |

THE NET FLOW INTO THE SYSTEM FROM FIXED GRADE NODES = 200.00
THE NET FLOW OUT OF THE SYSTEM INTO FIXED GRADE NODES = .00






SCALE - 1:6000 (BAR=300 M)

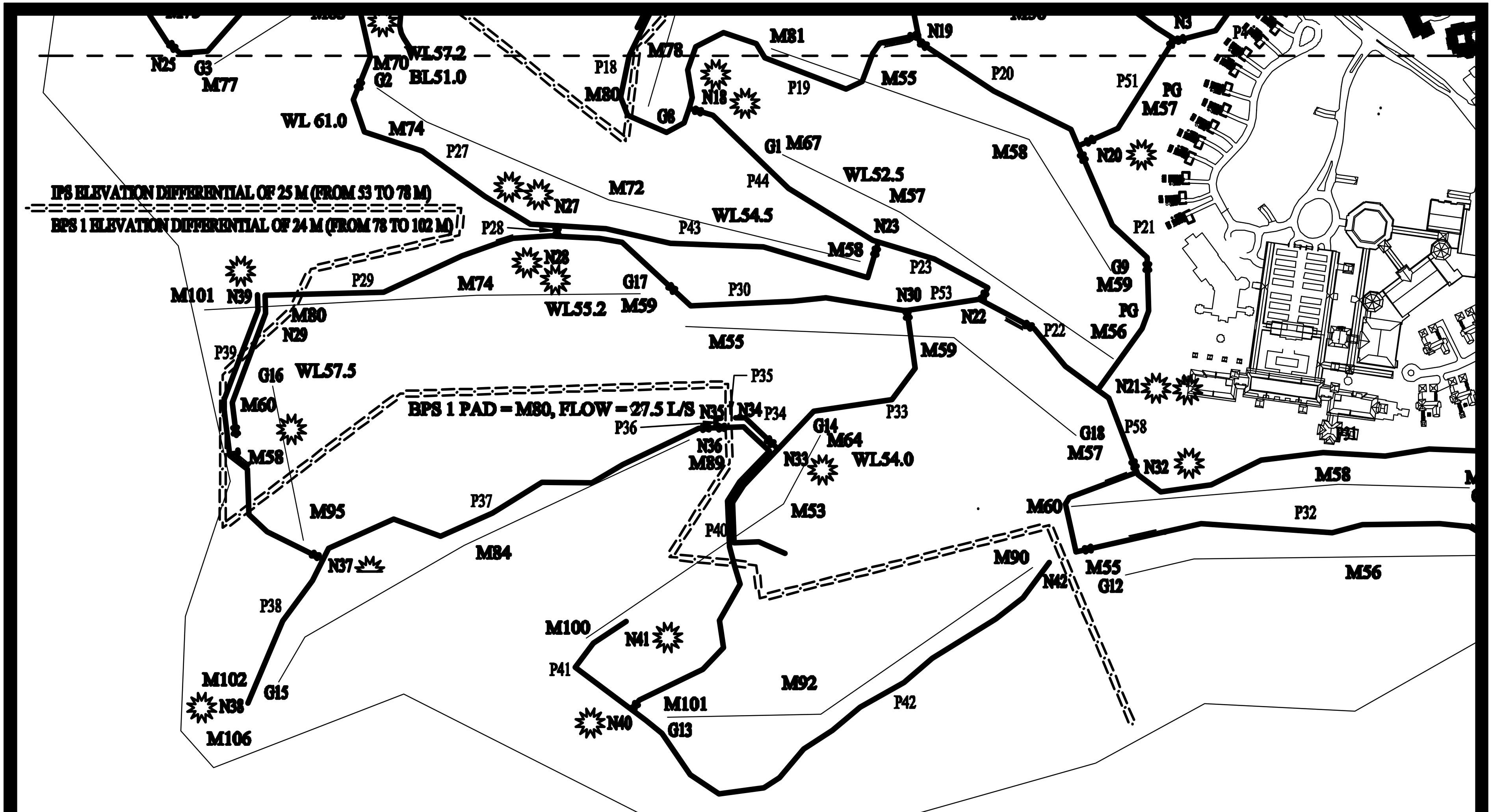
FILE: CHU_R1

WWW.HYDROGOLD.COM.AU

HYDRAULIC NETWORK ANALYSIS LEGEND
CHUNG HAU HOT SPRINGS GOLF COURSE

NXX - NODES
PXX - PIPES
MAINLINE

MXX - ELEVATIONS IN METRES
GXX - GREEN NUMBER
CENTRELINE OF PLAY

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SCALE - 1:6000 (BAR=300 M)

FILE: CHU_R1

WWW.HYDROGOLD.COM.AU

HYDRAULIC NETWORK ANALYSIS LEGEND
CHUNG HAU HOT SPRINGS GOLF COURSE

NXX - NODES
PXX - PIPES
MAINLINE
MXX - ELEVATIONS IN METRES
GXX - GREEN NUMBER
CENTRELINE OF PLAY

# 4 LATERAL LINE LOSSES

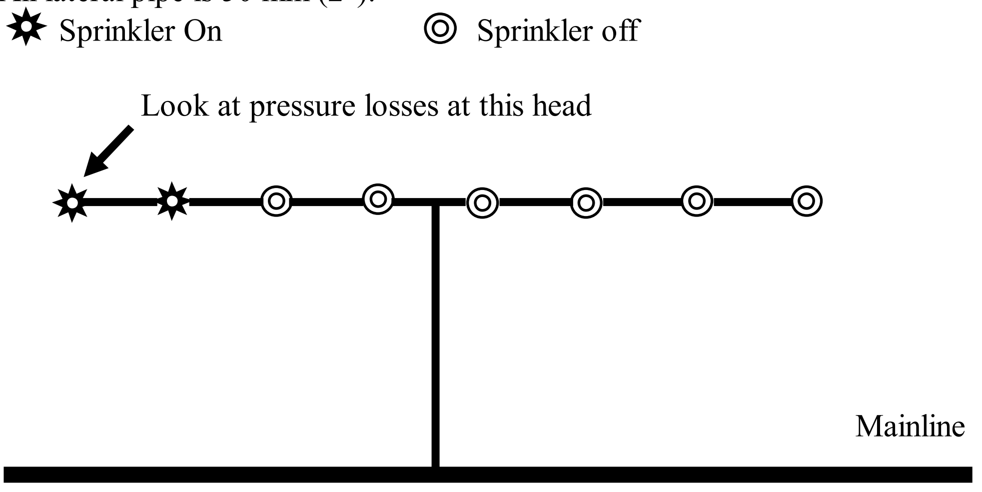
We look at each of the different styles of laterals used and look at worst case scenarios. The specific calculations for each case follow.

These calculations are then incorporated into the calculations for the pressures at the most critical points.

4.1 Lateral Losses for Tees - Straight Line - Valve in Head

**TYPICAL VIH TEE - Straight Line (2 heads simultaneously)**
**Typically 2 feeds per tee complex**

All lateral pipe is 50 mm (2").



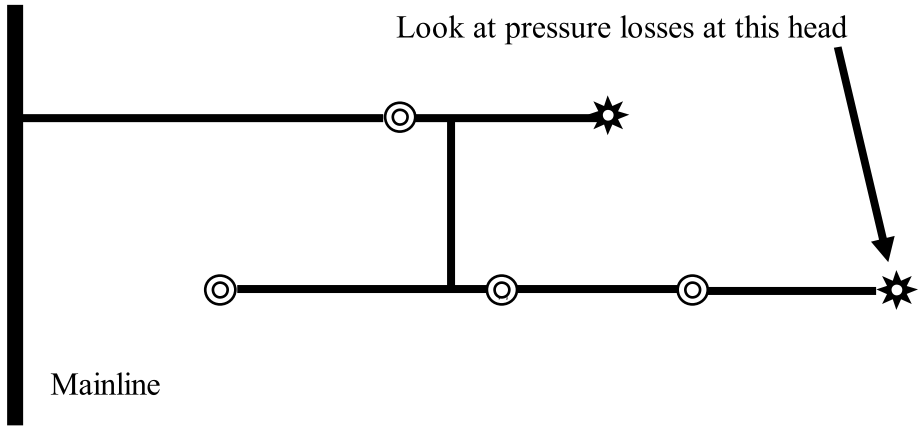

| PRESSURE LOSSES THROUGH INDIVIDUAL FITTINGS & PIPES | | | | | | | |
|---|---|---|---|---|---|---|---|
| Flow per Head (L/s) | | 1.41 | Head Spacing (m) | | | | 21.00 |
| Item | No Heads | Dia (Nom) | Dia (Act.) | Length (m) | K | Vel. (m/s) | Loss (kPa) |
| Tapping Saddle | 2 | 50.0 | 53.7 | | 1.00 | 1.25 | 0.78 |
| Elbow | 2 | 50.0 | 53.7 | | 1.10 | 1.25 | 0.85 |
| Gate Valve | 2 | 50.0 | 53.7 | | 0.15 | 1.25 | 0.12 |
| Pipe | 2 | 50.0 | 53.7 | 26.0 | | 1.25 | 7.41 |
| Tee - From Branch | 2 | 50.0 | 53.7 | | 1.00 | 1.25 | 0.78 |
| Pipe (2.5 * Spacing) | 2 | 50.0 | 53.7 | 52.5 | | 1.25 | 14.96 |
| Tee - In-line (2) | 1 | 50.0 | 53.7 | | 0.70 | 0.62 | 0.14 |
| Pipe (1 * Spacing) | 2 | 50.0 | 53.7 | 21.0 | | 1.25 | 5.99 |
| Tee - In-line | 1 | 50.0 | 53.7 | | 0.35 | 0.62 | 0.07 |
| Elbow | 1 | 50.0 | 53.7 | | 1.10 | 0.62 | 0.21 |
| Reducer | 1 | 25.0 | 29.8 | | 0.38 | 2.02 | 0.78 |
| Articulated Riser | 1 | 25.0 | 29.8 | | 3.30 | 2.02 | 6.75 |
| TOTAL LOSSES | | | | | | kPa | 38.82 |
| | | | | | | m | 3.96 |
| | | | | | | PSI | 5.63 |

4.2 Lateral Losses for Fairways - H Pattern - Valve in Head

**TYPICAL VIH FAIRWAY - (2 heads simultaneously per feed)**

All lateral pipe is 50 mm (2").

Sprinkler On    Sprinkler Off

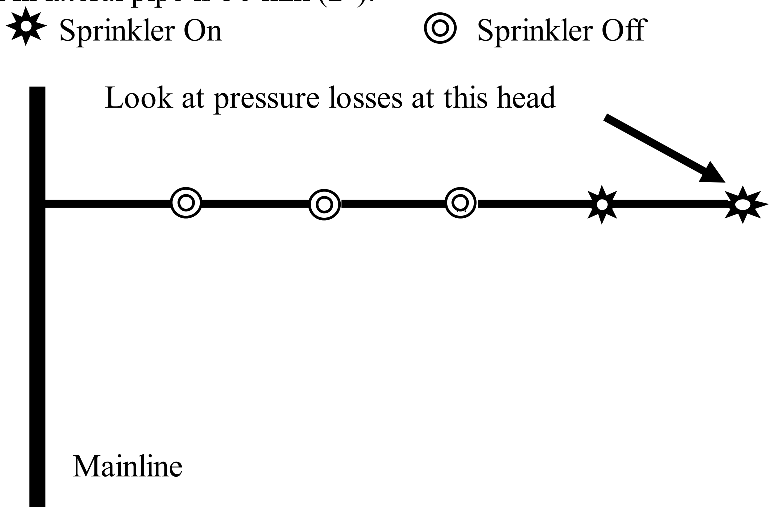



| PRESSURE LOSSES THROUGH INDIVIDUAL FITTINGS & PIPES | | | | | | | |
|---|---|---|---|---|---|---|---|
| Flow per Head (L/s) | | 1.41 | Head Spacing (m) | | | | 21.00 |
| Item | No Heads | Dia (Nom) | Dia (Act.) | Length (m) | K | Vel. (m/s) | Loss (kPa) |
| Tapping Saddle | 2 | 50.0 | 53.7 | | 1.00 | 1.25 | 0.78 |
| Elbow | 2 | 50.0 | 53.7 | | 1.10 | 1.25 | 0.85 |
| Gate Valve | 2 | 50.0 | 53.7 | | 0.15 | 1.25 | 0.12 |
| Pipe | 2 | 50.0 | 53.7 | 63.0 | | 1.25 | 17.96 |
| Tee - In-line | 2 | 50.0 | 53.7 | | 0.35 | 1.25 | 0.27 |
| Tee - To Branch | 1 | 50.0 | 53.7 | | 0.85 | 0.62 | 0.16 |
| Tee - From Branch | 1 | 50.0 | 53.7 | | 1.00 | 0.62 | 0.19 |
| Pipe | 1 | 50.0 | 53.7 | 5.0 | | 0.62 | 0.40 |
| Tee - In-line | 1 | 50.0 | 53.7 | | 0.35 | 0.62 | 0.07 |
| Pipe | 2 | 50.0 | 53.7 | 21.0 | | 1.25 | 5.99 |
| Elbow | 1 | 50.0 | 53.7 | | 1.10 | 0.62 | 0.21 |
| Reducer | 1 | 25.0 | 29.8 | | 0.38 | 2.02 | 0.78 |
| Articulated Riser | 1 | 25.0 | 29.8 | | 3.30 | 2.02 | 6.75 |
| TOTAL LOSSES | | | | | | kPa | 34.52 |
| | | | | | | m | 3.52 |
| | | | | | | PSI | 5.01 |

## 4.3 Lateral Losses for Fairways - 5 Sprinklers in a Straight Line - Valve in Head

**TYPICAL VIH FAIRWAY STRAIGHT LATERAL -**
**(5 in a line, 2 heads simultaneously per feed)**

All lateral pipe is 50 mm (2").




**PRESSURE LOSSES THROUGH INDIVIDUAL FITTINGS & PIPES**

| Flow per Head (L/s) | 1.41 | Head Spacing (m) | 21.00 |
|---|---|---|---|

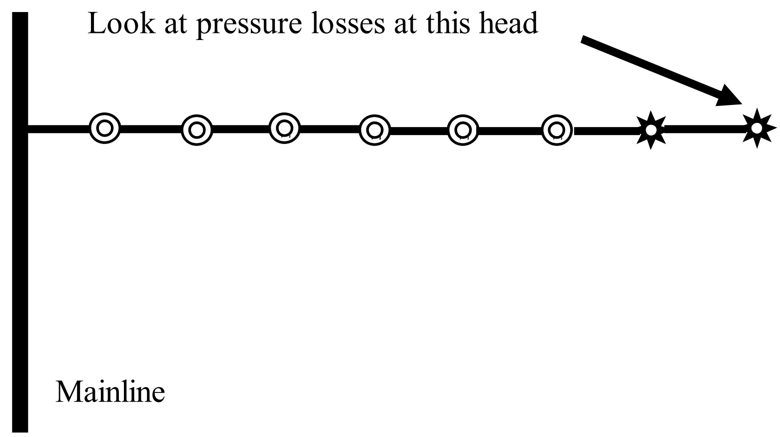
| Item | No Heads | Dia (Nom) | Dia (Act.) | Length (m) | K | Vel. (m/s) | Loss (kPa) |
|---|---|---|---|---|---|---|---|
| Tapping Saddle | 2 | 50.0 | 53.7 | | 1.00 | 1.25 | 0.78 |
| Elbow | 2 | 50.0 | 53.7 | | 1.10 | 1.25 | 0.85 |
| Gate Valve | 2 | 50.0 | 53.7 | | 0.15 | 1.25 | 0.12 |
| Pipe | 2 | 50.0 | 53.7 | 50.0 | | 1.25 | 14.25 |
| 3 Tees - In-line | 2 | 50.0 | 53.7 | | 1.05 | 1.25 | 0.81 |
| 3 Pipe lengths | 2 | 50.0 | 53.7 | 63.0 | | 1.25 | 17.96 |
| Tee - In-line | 2 | 50.0 | 53.7 | | 0.35 | 1.25 | 0.27 |
| Pipe | 1 | 50.0 | 53.7 | 21.0 | | 0.62 | 1.66 |
| Elbow | 1 | 50.0 | 53.7 | | 1.10 | 0.62 | 0.21 |
| Reducer | 1 | 25.0 | 29.8 | | 0.38 | 2.02 | 0.78 |
| Articulated Riser | 1 | 25.0 | 29.8 | | 3.30 | 2.02 | 6.75 |
| TOTAL LOSSES | | | | | | kPa | 44.44 |
| | | | | | | m | 4.53 |
| | | | | | | PSI | 6.45 |

4.4 Lateral Losses for Fairways - 8 Sprinklers in a Straight Line - Valve in Head

**TYPICAL VIH FAIRWAY STRAIGHT LATERAL -**
**(8 in a line, 2 heads simultaneously per feed)**

All lateral pipe is 50 mm (2").

✲ Sprinkler On ◎ Sprinkler Off




**PRESSURE LOSSES THROUGH INDIVIDUAL FITTINGS & PIPES**

| Flow per Head (L/s) | 1.41 | Head Spacing (m) | 21.00 |
|---|---|---|---|

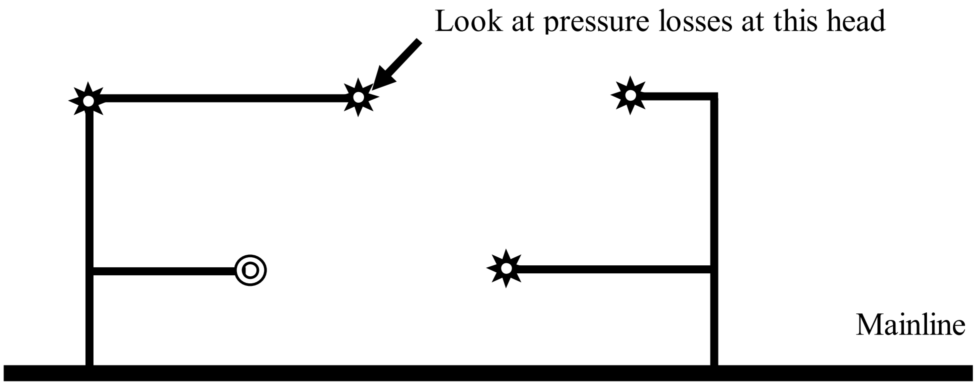
| Item | No Heads | Dia (Nom) | Dia (Act.) | Length (m) | K | Vel. (m/s) | Loss (kPa) |
|---|---|---|---|---|---|---|---|
| Tapping Saddle | 2 | 50.0 | 53.7 | | 1.00 | 1.25 | 0.78 |
| Elbow | 2 | 50.0 | 53.7 | | 1.10 | 1.25 | 0.85 |
| Gate Valve | 2 | 50.0 | 53.7 | | 0.15 | 1.25 | 0.12 |
| Pipe | 2 | 50.0 | 53.7 | 50.0 | | 1.25 | 14.25 |
| 6 Tees - In-line | 2 | 50.0 | 53.7 | | 2.10 | 1.25 | 1.63 |
| 6 Pipe lengths | 2 | 50.0 | 53.7 | 126.0 | | 1.25 | 35.91 |
| Tee - In-line | 2 | 50.0 | 53.7 | | 0.35 | 1.25 | 0.27 |
| Pipe | 1 | 50.0 | 53.7 | 21.0 | | 0.62 | 1.66 |
| Elbow | 1 | 50.0 | 53.7 | | 1.10 | 0.62 | 0.21 |
| Reducer | 1 | 25.0 | 29.8 | | 0.38 | 2.02 | 0.78 |
| Articulated Riser | 1 | 25.0 | 29.8 | | 3.30 | 2.02 | 6.75 |
| TOTAL LOSSES | | | | | | kPa | 63.21 |
| | | | | | | m | 6.44 |
| | | | | | | PSI | 9.17 |

## 4.5 Lateral Losses for Large Greens - Valve in Head

**TYPICAL VIH GREEN -**
**2 or 3 Feeds (2 heads simultaneously per feed)**

All lateral pipe is 50 mm (2").

✹ Sprinkler On ◎ Sprinkler off




**PRESSURE LOSSES THROUGH INDIVIDUAL FITTINGS & PIPES**

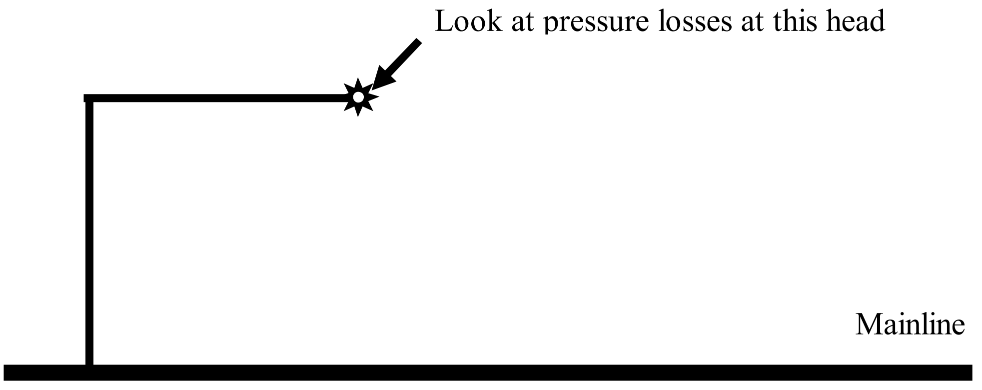
| Flow per Head (L/s) | | 2.14 | Head Spacing (m) | | | | 24.00 |
|---|---|---|---|---|---|---|---|
| Item | No Heads | Dia (Nom) | Dia (Act.) | Length (m) | K | Vel. (m/s) | Loss (kPa) |
| Tapping Saddle | 2 | 50.0 | 53.7 | | 1.00 | 1.89 | 1.79 |
| Elbow | 2 | 50.0 | 53.7 | | 1.10 | 1.89 | 1.97 |
| Gate Valve | 2 | 50.0 | 53.7 | | 0.15 | 1.89 | 0.27 |
| Pipe | 2 | 50.0 | 53.7 | 36.0 | | 1.89 | 22.21 |
| Tee - In-line | 2 | 50.0 | 53.7 | | 0.35 | 1.89 | 0.63 |
| Pipe | 2 | 50.0 | 53.7 | 20.8 | | 1.89 | 12.82 |
| Tee - In-line | 2 | 50.0 | 53.7 | | 0.35 | 1.89 | 0.63 |
| Elbow | 2 | 50.0 | 53.7 | | 1.10 | 1.89 | 1.97 |
| Pipe | 1 | 50.0 | 53.7 | 24.0 | | 0.94 | 4.10 |
| Elbow | 1 | 50.0 | 53.7 | | 1.10 | 0.94 | 0.49 |
| Reducer | 1 | 25.0 | 29.8 | | 0.38 | 3.07 | 1.79 |
| Articulated Riser | 1 | 25.0 | 29.8 | | 3.30 | 3.07 | 15.55 |
| TOTAL LOSSES | | | | | | kPa | 64.21 |
| | | | | | | m | 6.54 |
| | | | | | | PSI | 9.32 |

4.6 Lateral Losses for Driving Range Tee - Valve in Head

**TYPICAL DRIVING RANGE TEE -**
**(Only 1 head at a time per lateral feed)**

All lateral pipe is 50 mm (2").

✲ Sprinkler On ◎ Sprinkler off

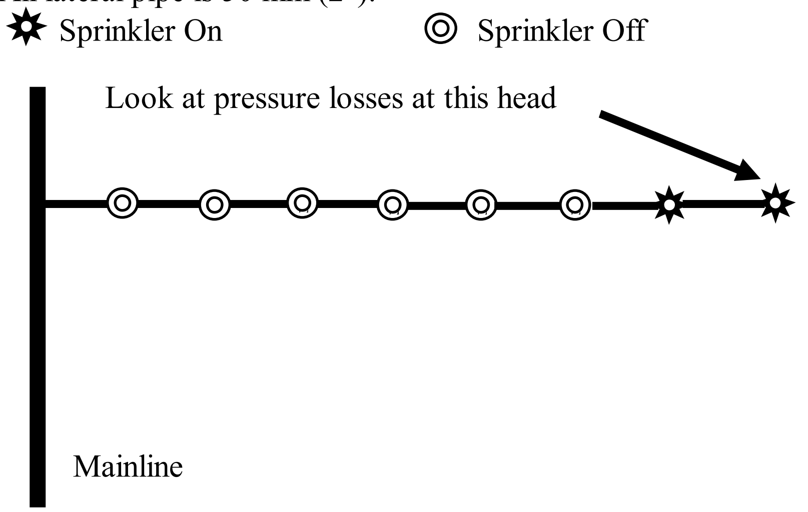



| PRESSURE LOSSES THROUGH INDIVIDUAL FITTINGS & PIPES | | | | | | | |
|---|---|---|---|---|---|---|---|
| Flow per Head (L/s) | | 2.92 | Head Spacing (m) | | | | 30.00 |
| Item | No Heads | Dia (Nom) | Dia (Act.) | Length (m) | K | Vel. (m/s) | Loss (kPa) |
| Tapping Saddle | 1 | 50.0 | 53.7 | | 1.00 | 1.29 | 0.83 |
| Elbow | 1 | 50.0 | 53.7 | | 1.10 | 1.29 | 0.92 |
| Gate Valve | 1 | 50.0 | 53.7 | | 0.15 | 1.29 | 0.12 |
| Pipe | 1 | 50.0 | 53.7 | 50.0 | | 1.29 | 15.20 |
| Elbow | 1 | 50.0 | 53.7 | | 1.10 | 1.29 | 0.92 |
| Pipe | 1 | 50.0 | 53.7 | 10.0 | | 1.29 | 3.04 |
| Elbow | 1 | 50.0 | 53.7 | | 1.10 | 1.29 | 0.92 |
| Reducer | 1 | 40.0 | 38.0 | | 0.38 | 2.57 | 1.26 |
| Articulated Riser | 1 | 40.0 | 38.0 | | 3.30 | 2.57 | 10.95 |
| TOTAL LOSSES | | | | | | kPa | 34.15 |
| | | | | | | m | 3.48 |
| | | | | | | PSI | 4.96 |

## 4.7 Lateral Losses for Driving Range - Straight Line - Valve in Head

**TYPICAL VIH DRIVING RANGE STRAIGHT LATERAL -**
**(8 in a line, 2 heads simultaneously per feed)**

All lateral pipe is 50 mm (2").




**PRESSURE LOSSES THROUGH INDIVIDUAL FITTINGS & PIPES**

| Flow per Head (L/s) | 2.14 | Head Spacing (m) | 24.00 |
|---|---|---|---|

| Item | No Heads | Dia (Nom) | Dia (Act.) | Length (m) | K | Vel. (m/s) | Loss (kPa) |
|---|---|---|---|---|---|---|---|
| Tapping Saddle | 2 | 50.0 | 53.7 | | 1.00 | 1.89 | 1.79 |
| Elbow | 2 | 50.0 | 53.7 | | 1.10 | 1.89 | 1.97 |
| Gate Valve | 2 | 50.0 | 53.7 | | 0.15 | 1.89 | 0.27 |
| Pipe | 2 | 50.0 | 53.7 | 50.0 | | 1.89 | 30.85 |
| 6 Tees - In-line | 2 | 50.0 | 53.7 | | 2.10 | 1.89 | 3.75 |
| 6 Pipe lengths | 2 | 50.0 | 53.7 | 144.0 | | 1.89 | 88.84 |
| Tee - In-line | 2 | 50.0 | 53.7 | | 0.35 | 1.89 | 0.63 |
| Pipe | 1 | 50.0 | 53.7 | 24.0 | | 0.94 | 4.10 |
| Elbow | 1 | 50.0 | 53.7 | | 1.10 | 0.94 | 0.49 |
| Reducer | 1 | 25.0 | 29.8 | | 0.38 | 3.07 | 1.79 |
| Articulated Riser | 1 | 25.0 | 29.8 | | 3.30 | 3.07 | 15.55 |
| TOTAL LOSSES | | | | | | kPa | 150.02 |
| | | | | | | m | 15.28 |
| | | | | | | PSI | 21.77 |

# 5 TRANSFER PUMP STATIONS

## 5.1 Safety Backup

### 5.1.1 Transfer Pump Stations 1 and 2

The transfer of water from the river is absolutely critical since the irrigation lake only contains sufficient water for 3 days (at full use).

Transfer Pump Stations Nos 1 and 2 are identical. It is intended that both of them operate simultaneously for the 12 hour pumping window to transfer the required volume of water.

However, if one of the pumps should fail, the other pump can be used 24 hours a day (on a temporary basis while repairs are made) to pump the required volume.

### 5.1.2 Transfer Pump Station No 3

This is not a critical function and therefore no backup has been provided for this pump station.

Transfer pump is to raise the level of the lake on hole 3/4 by 100 mm (4") in 27 hours. 27 (and not 24) hours was chosen since the resultant flow fits in better with pump selections.

Lake Area = 19,653 m^2
Volume to pump = 1,956 m^3 (=19653*0.1) $m^3$
Time to Pump = 27 Hours

## 5.2 Use of (Submersible) Drainage Pump

We use Drainage Pumps in preference to more standard End Suction (Centrifugal) Pumps. While there are advantages and disadvantages (see below) for each pump type, we believe it is both a lower cost and better solution for this particular application.

### 5.2.1 Advantages

a) No loss of prime - More reliable pump operation.

b) More efficient, particularly at the low Total Dynamic Head - Lower electricity costs

c) No intake structure - Lower cost for support infrastructure.

d) Better quality pump - Last longer - Lower cost of ownership.

e) Below water - Out of sight - Better aesthetics - Less opportunity for vandalism

5.2.2 Disadvantages

a) The pump is slightly more expensive but this is more than offset by the elimination of the intake structure.

b) Harder to access for maintenance - Higher maintenance costs.

c) The pump pad should be poured before there is water is in the lake - Need for planning.

5.3 Our calculations follow:

| **TRANSFER PUMP PERFORMANCE - Section 1** | | **TPS 1 & 2** | **TPS 3** |
|---|---|---|---|
| **Description** | **Unit** | **Quantity** | **Quantity** |
| **FLOWS** | | | |
| Volume to Pump | cu m | 2,960 | 1,965 |
| | US Gal | 783,020 | 519,841 |
| Time to Pump | Hours | 12 | 27 |
| **Pump Flow Rate** | L/s | 69 | 20 |
| | USGPM | 1,088 | 321 |
| **LEVEL PARAMETERS** | | | |
| Lake Floor Level | m | L. 48.0 | L. 51.0 |
| | feet | L. 157.4 | L. 167.3 |
| Low Water Level of Lake for Pumping (Bottom Level of Intake) | m | L. 48.5 | L. 51.5 |
| | feet | L. 159.1 | L. 168.9 |
| High Water Level of Lake or Flood Level (whichever is greater) | m | L. 51.0 | L. 57.2 |
| | feet | L. 167.3 | L. 187.6 |
| Level of Pump Station Pad | m | L. 48.0 | L. 51.0 |
| | feet | L. 157.4 | L. 167.3 |
| Distance from Pump Station to Worst Case Intermediate Point | m | 20 | 120 |
| | feet | 66 | 394 |
| Level at Worst Case Intermediate Point | m | L. 54.0 | L. 69.0 |
| | feet | L. 177.1 | L. 226.3 |
| Distance from Pump Station to Discharge Point | m | 20 | 100 |
| | feet | 66 | 328 |
| Level at Discharge Point | m | L. 53.0 | L. 66.5 |
| | feet | L. 173.8 | L. 218.1 |
| Note: The symbol 'L.' represents a level from the datum. | | | |

| TRANSFER PUMP PERFORMANCE - Section 2 | | TPS 1 & 2 | TPS 3 |
|---|---|---|---|
| **Description** | **Unit** | **Quantity** | **Quantity** |
| **ELECTRIC POWER PARAMETERS** | | | |
| Number of Pumps | No | 1 | 1 |
| Cost of Electricity | US$/kW.Hr | 0.10 | 0.10 |
| No Hours to Run Per Day | Hr | 12.00 | 24.00 |
| No Days to Run per Year | days/yr | 200 | 100 |
| **PIPE FLOW CALCULATIONS** | | | |
| Pipe Flow Rate | L/s | 69 | 20 |
| (Intake Flow = Discharge Flow) | USGPM | 1,088 | 321 |
| Intake Line - Internal Diameter | mm | 450 | 250 |
| (from Lake to Wet Well) | Inches | 18 | 10 |
| Intake Line Velocity | m/s | 0.43 | 0.41 |
| | ft/s | 1.41 | 1.35 |
| Discharge Line - Internal Diameter | mm | 200 | 150 |
| (from Pump to Field) | Inches | 8 | 6 |
| Discharge Line Velocity | m/s | 2.18 | 1.14 |
| | ft/s | 7.15 | 3.75 |
| **ELECTRIC POWER CALCULATIONS** | | | |
| **Total Dynamic Head** | m | 6 | 20 |
| (From Low Water Level)<br>(10% Extra capacity) | PSI | 9 | 29 |
| Estimated Total Power for Electric | kW | 8.0 | 7.4 |
| Motors (60% pump efficiency) | Hp | 10.7 | 10.0 |
| Peak Power Demand | kW | 16.0 | 14.9 |
| | Hp | 21.5 | 19.9 |
| Daily Electricity Cost | US$/day | 9.61 | 17.83 |
| Yearly Electricity Cost | US$/yr | 1,922.90 | 1,783.36 |