APPENDIX 12

Hatch Mott MacDonald

Borough of Madison

Water System Critical Component Analysis

December 2003

Hatch Mott MacDonald

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December 29, 2003

Mr. Robert A. Vogel, PE
Borough Engineer
Borough of Madison
Hartley Dodge Memorial Building
50 Kings Road
Madison, NJ 07940

RE: 207484 – Borough of Madison
Water System Critical Component Analysis

Dear Mr. Vogel:

In accordance with our proposal, we are pleased to submit herein the Water System Critical Component analysis for the Borough. Following your review, we would be pleased to meet with you to discuss any questions or comments you may have.

Very truly yours,

Hatch Mott MacDonald

Earl C. Schneider

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Hatch Mott MacDonald

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Letter of Transmittal

1.0 Introduction

The Borough of Madison owns and operates a water utility that provides potable water supply for domestic and fire fighting purposes to a population of approximately 17,000 persons. The Borough is charged with the mission of providing a reliable supply of water of high quality to its customers. This study was requested by the Borough to provide a comprehensive evaluation of the water supply system to determine the system's ability to maintain service with "critical" components out-of-service, primarily well supplies and tank storage.

This study utilizes a computer hydraulic model of the system to analyze several "what-if" scenarios associated with the loss of critical components of the water system; to determine any potential weaknesses in the system. An evaluation of emergency interconnection capacity to maintain service is also included.

Based upon the study findings, recommendations are provided for water system improvements to reduce the consequences of losing the operation of one or more critical assets. This also includes recommendations related to operational policies to improve water system functionality.

2.0 General Description of Water System

The Borough of Madison supplies an average of approximately 2.1 million gallons per day (MGD) and a peak of approximately 4.3 MGD to its customer base. Water is supplied from five wells with the following approximate capacities:

- Well A 900 gpm (gallons per minute)
- Well B 1,100 gpm
- Well C 1,200 gpm
- Well D 1,200 gpm (currently not-in-service)
- Well E 1,100 gpm

Total 5,500 gpm (7.92MGD)

The Borough has an NJDEP Water allocation permit allows the Borough to divert a maximum of 108.5 million gallons per month (3.56MGD), and at a maximum pumping rate of 4.150GPM (5.98MGD).

Wells A and B are provided treatment to remove volatile organic chemicals (VOCs) at a central treatment facility located adjacent to Well A on John Avenue. Refer to Plate 2.1 for an overall map of the water system.

Water is stored in two elevated tanks: Midwood Tank (750,000 gallons); and Madison Tank (500,000 gallons).

The Borough has emergency interconnections with: (3) New Jersey-American Water Company; (1) Southeast Morris County Municipal Utilities Authority; and the (3) Borough of Florham Park.

The Well A&B VOC treatment facility, Well C, Well D, and Well E all are outfitted with standby power that can maintain well supply and pumping operations in the event of power failure. The following table describes the standby power availability.

Location	Standby Power	Size	Fuel Storage (volume/run hours)
Well A	From WTP generator		
Well B	Diesel Generator	30 KW	10 gals/2 hours
Well C	Diesel Rt Angle Drive		60 gals/4 hours
Well D	Diesel Generator	30 KW	10 gals/1 hour
Well E	Gas Rt Angle Drive		10 gals/1 hour
Well A&B WTP	Diesel Generator	500 KW	800 gals./24 hours

Although standby power exists at all well facilities, only Well A, Well B, and the associated treatment plant have any significant fuel storage. It is recommended that additional storage (at least 12 hours) be provided at all well sources.

3.0 Critical Component Analysis

In order to maintain a reliable water supply to the Borough's residents and customers, the system must be capable of providing satisfactory supply and pressure under a variety of demand conditions. In addition, water tanks within the system must maintain a sufficient water reserve for fire protection, equalization of supply during peak demands, and emergency reserve.

In addition, the water system must be able to provide supply, pressure, and storage in the event that one or more components of the system are not in service. The NJDEP requires that water systems have "firm capacity", measured as supply capacity with the largest supply component out of service, at least equal to the maximum day demands in the system. The NJDEP also requires tank storage as a function of average day demand, interconnection capacity with outside purveyors, and availability of standby power at supply sources.

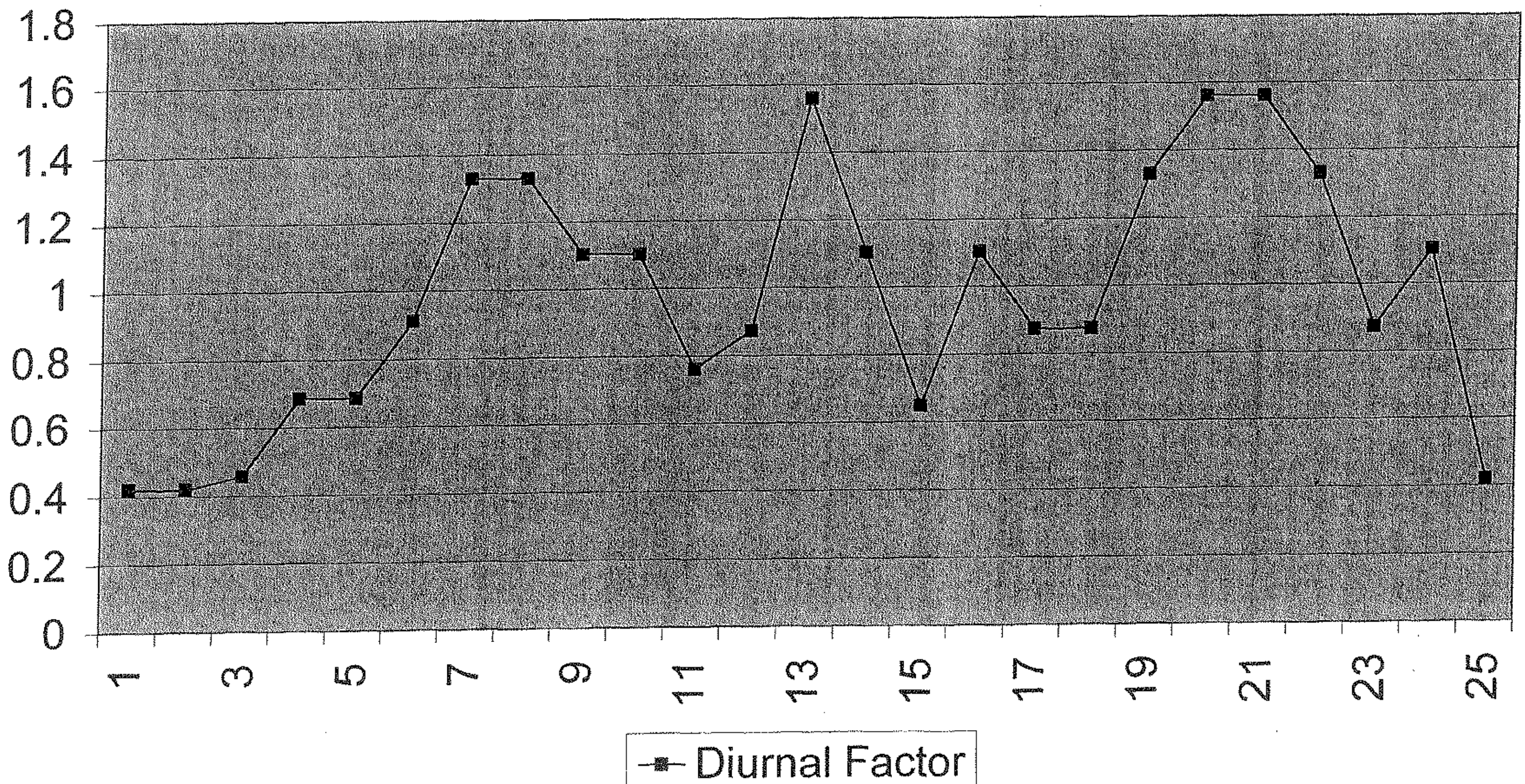
A computer hydraulic model can be used to evaluate pressure and supply capacity, and tank storage with critical facilities out of service. Hatch Mott MacDonald recently developed a computer model and report for the Borough (*Hydraulic Model of Water System*, February, 2003) and performed calibration satisfactory for this study.

3.1 Development of Diurnal Curve

To determine the criticality of facilities in the system, modeling was performed using Extended Period Simulations (EPS). An EPS is a modeling technique that allows the system to be modeled over the course of many hours or days to determine parameters, such as, pressures and tank filling patterns. In order to perform an EPS, a diurnal curve is developed that simulates the percent of water usage on an hourly basis over the course of a day.

For the Borough of Madison, chart recorder information from the Water Department, which indicated well supply, and tank levels over the course of a day was reviewed. From this information the diurnal curve shown on Figure 3.1 that shows water usage for July 6, 1999, which was a day of historical maximum demand was developed. The chart indicates low water usage in the middle of the night, and higher water usage during the morning and evening hours. The evening water usage likely corresponds to lawn water sprinkling.

Borough of Madison
Water Usage Diurnal Curve - July, 1999
Figure 3.1



3.2 Water Demands

In order to develop an accurate model, actual water demands need to be input into the model. In order to assess future conditions, planned future development needs to also be included. The Borough provided information on several developments outlined in the following table, that represent planned increase in water demands over the next five years:

Description	Location	Type	Square Feet	Water Usage (gpd)
Sunrise Development	B 201 L1	Residential		41,000
Reckson Partnership at Giralda Farms	B 3202 L1	Commercial	436,000	54,500
Drew Academic Arts Center in Madison Ave	B 3001 L1	Commercial	57,000	7,125
			Total	**102,625**

Commercial water usage based upon 0.125 gpd/sf per NJAC 7:10-12.6b Table 1

A summary of existing and future (5 year planning horizon) water demands within the water system is as follows:

Scenario	Existing Demand (MGD)	Future Demand (MGD) 5 Year Planning Horizon
Average Day	2.1 MGD	2.2 MGD
Maximum Day	4.2 MGD	4.4 MGD
Peak Hour	5.4 MGD	5.7 MGD

3.3 Hydraulic Modeling Scenarios

The hydraulic analysis needs to consider the likely scenarios where facilities may be out of service, and when operations of facilities can significantly change system hydraulics. Based upon conversations with Borough personnel, the normal operation of the system includes Wells A, C, and E in operation, with supplemental supply provided from Well B if required. As noted previously, Well D is currently not in operation.

The approach to the analysis was to establish a baseline of normal operation of the water system during maximum day demand conditions over a 72-hour (three day) period, and then remove facilities from service and/or modify

Borough of Madison
Water System Critical Component Analysis
Critical Location Analysis
Table 3-1

				Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6		Scenario 7	
Location	**Ground Elevation (ft)**	**Measurement**	**Unit**	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Midwood Tank	372	Calculated Hydraulic Grade	ft	462.71	472.97	452.23	472.88	457.42	473.00	454.68	480.36	460.78	473.00	446.33	472.88	467.65	472.92
		Pressure	psi	39.24	43.68	34.71	43.65	36.96	43.70	35.77	46.88	38.41	43.70	32.16	43.65	41.38	43.66
Madison Tank	378	Calculated Hydraulic Grade	ft	461.52	472.76	447.78	471.79	454.93	481.84	453.22	472.00	459.21	473.13	441.89	471.79	465.04	476.41
		Pressure	psi	36.14	41.00	30.19	40.58	33.28	44.93	32.55	40.67	35.14	41.16	27.64	40.58	37.66	42.58
Linden Drive	366	Calculated Hydraulic Grade	ft	462.26	473.52	449.57	472.48	456.03	480.22	454.60	475.10	460.28	473.52	443.68	472.48	465.69	475.93
		Pressure	psi	41.46	46.33	35.97	45.88	38.77	49.23	38.15	47.02	40.60	46.33	33.42	45.88	42.94	47.38
Woodcliff Drive	374	Calculated Hydraulic Grade	ft	462.38	474.56	449.65	472.61	456.25	480.93	454.63	476.64	460.01	474.56	443.76	472.61	465.69	476.26
		Pressure	psi	38.19	43.46	32.68	42.61	35.53	46.21	34.83	44.35	37.16	43.46	30.13	42.61	39.62	44.19
Winding Way	366	Calculated Hydraulic Grade	ft	463.92	478.93	457.00	481.35	459.40	481.05	455.80	484.93	462.66	478.93	451.16	481.35	467.55	480.33
		Pressure	psi	42.16	48.66	39.17	49.70	40.21	49.57	38.65	51.25	41.62	48.66	36.64	49.70	43.73	49.26
Broadview Ave	367	Calculated Hydraulic Grade	ft	464.59	478.62	456.95	480.66	459.68	480.65	456.05	484.62	462.93	478.62	451.11	480.66	467.78	479.79
		Pressure	psi	42.18	48.25	38.88	49.14	40.06	49.13	38.49	50.85	41.47	48.25	36.35	49.14	43.56	48.76
N. Oak Circle	387	Calculated Hydraulic Grade	ft	461.55	472.56	447.85	471.74	454.82	481.69	453.54	471.99	459.53	473.10	441.96	471.74	465.04	476.38
		Pressure	psi	32.33	37.09	26.40	36.74	29.42	41.04	28.86	36.84	31.45	37.33	23.85	36.74	33.84	38.74
PMP-Well C		Flow	gpm	0.00	1224.78	0.00	0.00	0.00	1242.76	0.00	1245.71	0.00	1230.24	0.00	0.00	0.00	0.00
	219	Calculated Hydraulic Grade	ft	465.33	480.22	449.03	472.89	458.89	486.80	457.81	481.44	463.39	480.22	443.14	472.89	465.16	477.09
		Pressure	psi	106.38	112.82	99.32	109.65	103.59	115.67	103.12	113.35	105.54	112.82	96.77	109.65	106.30	111.46
PMP-Well E		Flow	gpm	0.00	1133.05	0.00	1124.83	0.00	1145.39	0.00	1150.35	0.00	1137.12	0.00	1137.77	0.00	1118.02
	208	Calculated Hydraulic Grade	ft	468.05	501.73	468.44	515.63	466.06	505.82	473.60	505.56	468.07	501.73	468.44	515.63	466.67	503.03
		Pressure	psi	112.51	127.08	112.68	133.10	111.65	128.85	114.91	128.74	112.52	127.08	112.68	133.10	111.91	127.64
Well A&B WTP Pump No. 1		Flow	gpm	0.00	1270.82	0.00	1000.00	0.00	1276.79	1169.07	1255.05	0.00	1270.77	0.00	1000.00	0.00	1258.25
Well A&B WTP Pump No. 2		Flow	gpm	0.00	0.00	0.00	1000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1000.00	0.00	0.00
WTP A&B	200	Calculated Hydraulic Grade	ft	469.25	498.54	468.44	514.02	467.17	502.74	474.68	502.32	468.17	498.54	468.44	514.02	466.67	499.72
		Pressure	psi	116.49	129.16	116.14	135.86	115.59	130.98	118.84	130.80	116.02	129.16	116.14	135.86	115.37	129.67
Well D	233	Calculated Hydraulic Grade	ft	463.62	478.56	449.08	473.01	457.21	485.07	455.99	479.91	461.68	478.56	443.19	473.01	465.19	477.13
		Pressure	psi	99.59	106.06	93.30	103.65	96.82	108.87	96.29	106.64	98.75	106.06	90.75	103.65	100.27	105.44

Midwood Tank Range Full Elevation 474 feet Empty Elevationn 430 feet
Madison Tank Range Full Elevation 474 feet Empty Elevation 435 feet

pumping operations to find potential hydraulic weaknesses in the system. The following scenarios were modeled under *maximum day demand* conditions:

Scenario 1)	Baseline analysis with Wells A, C, and E in operation (normal operation)
Scenario 2)	Scenario 1 with Well C out-of-service and Well B in-service
Scenario 3)	Scenario 1 with Madison Tank out-of-service
Scenario 4)	Scenario 1 with Midwood Tank out-of-service
Scenario 5)	Scenario 1 with 2 hour, 2,000 gpm fire flow on Main Street
Scenario 6)	Scenario 2 with 2 hour, 2,000 gpm fire flow on Main Street

It is noted, that no scenario was performed with the Well A&B Treatment Plant out-of-service during maximum day demand conditions, because without this facility the system would not be able to provide enough supply to meet customer demands (without the use of an interconnection).

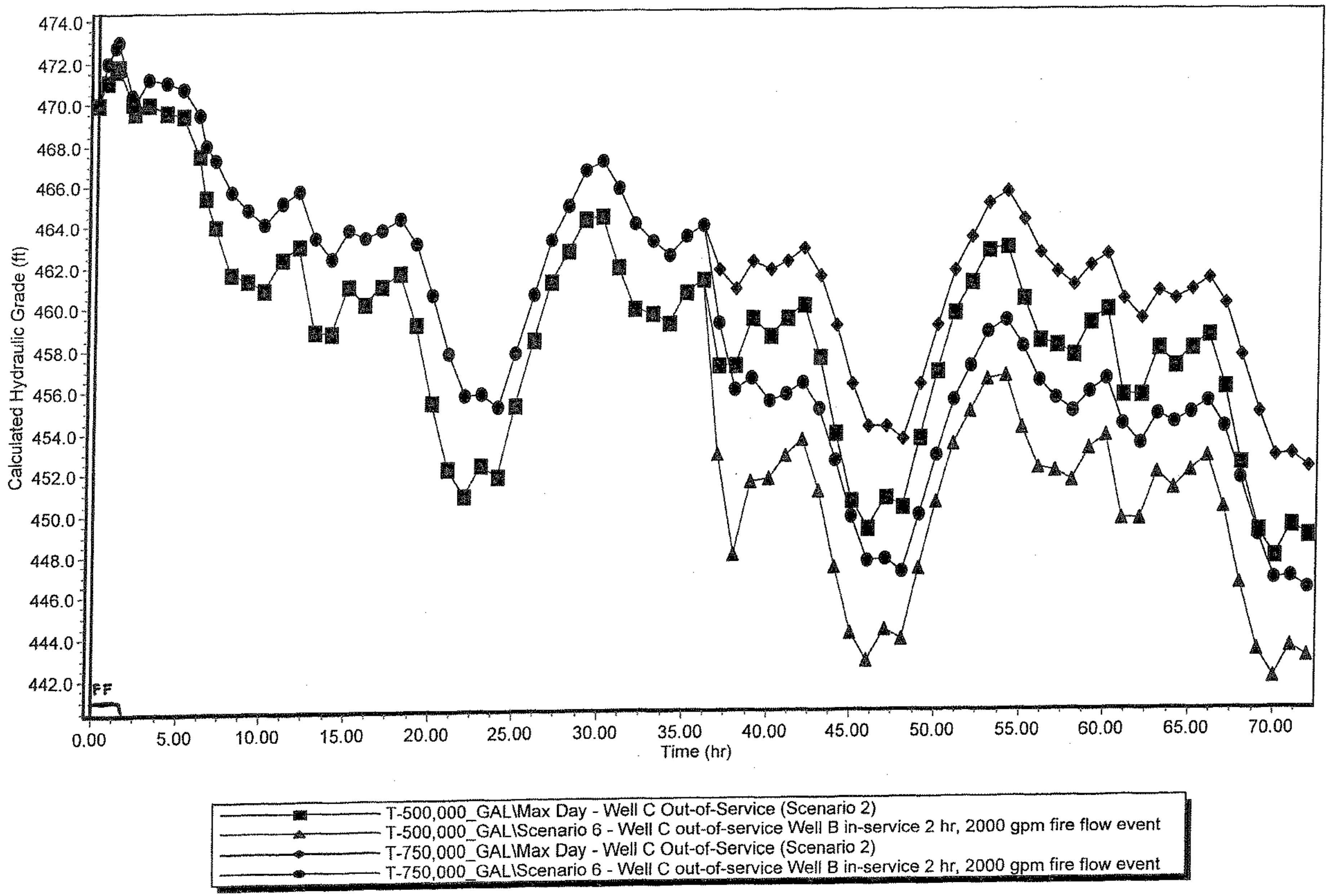
An additional scenario was performed considering both a tank and well out of service. This is considered a low probability event (two major facilities) out-of-service, and was evaluated under *average day demand* conditions:

Scenario 7) Madison Tank out-of-service with Well C out-of-service

Table 3.1 provides hydraulic model output data for the above modeling scenarios for twelve selected locations within the system. These locations include tanks, wells, and high ground elevations (low-pressure areas) within the system. The output includes minimum and maximum values for pressure, flow, and calculated hydraulic gradeline (HGL) at these locations during the 72-hour modeling runs. A review of the modeling output provides the following relevant information:

- Without Well D, the system is susceptible to storage loss under Scenarios 2 and 6. The storage loss at the tanks for Scenarios 2 and 6 are indicated on Figure 3-2. Wells A, B and E combined cannot adequately supply the system under maximum day demand conditions without contribution from either Well C or Well D. In general, any three wells combined do not have adequate capacity to supply water under maximum day demands, and a fourth well is needed. The analyses indicate the criticality of Well D to provide system redundancy. It is noted that emergency interconnection capacity from New Jersey-American Water Company was not analyzed under these scenarios, and is discussed in a subsequent section of this report.

Storage Loss with Well C Out-of-Service During Maximum Day Demand Conditions
Figure 3-2



- Scenario 2 indicates that when pumping Well A and B together (via the VOC Treatment Plant), there is approximately a 10 psi increase in pressure near the treatment plant (from 120 psi to 130 psi). Water department personnel have indicated that this increase in pressure is a likely reason for recent main breaks on the 10-inch diameter main in the vicinity of Bruns Street. This main was installed in the late 1940s with "leadite" joints that have failed under increased pressure. Leadite, a plasticized sulfur cement, was a wartime lead substitute. Leadite also expands at a different rate than iron due to temperature changes, resulting in longitudinal splits in the pipe bell.

- Fire protection during maximum day demands can impact storage in the short-term. The tanks will recover as long as all currently operating wells (Wells A, B, C and E) are in service. Once again, the value of Well D as a redundant source is demonstrated.

3.4 Evaluation of Water Storage Capacity

The Borough of Madison has two tanks described as follows:

- **Madison Tank** – a 500,000 gallon elevated tank located near the intersection of Madison Avenue and Danforth Road. The tank is 55 feet in diameter with an overflow elevation of 474 feet above sea level. The tank stores approximately 16,600 gallons per foot over a range of 30 feet. Figure 3.3 provides the tank capacity at different levels of depth.

- **Midwood Tank** – a 750,000 gallon elevated tank located near the intersection of Midwood Terrace and Prospect Street. The tank is 60 feet in diameter with an overflow elevation of 474 feet above sea level The tank stores approximately 17,500 gallons per foot over a range of 43 feet. Figure 3.4 provides the tank capacity at different levels of depth.

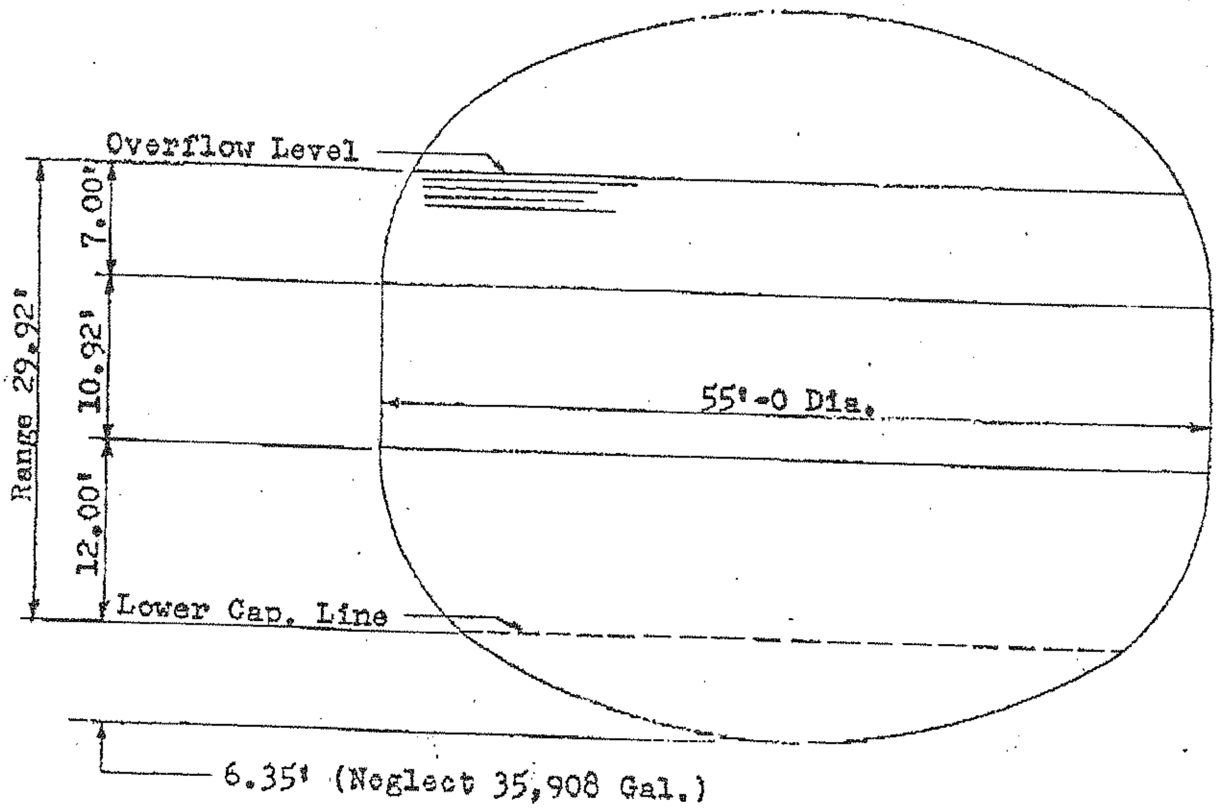
Tanks are sized to provide three components of storage:

- **Equalization** – during daily peak demands outflow from tanks provide supply to maintain pressure in the system. For example, although the maximum day demand is 4.5 MGD, the peak rate of supply needed during the peak hour(s) of the day is estimated at approximately 7 MGD. This is based upon multiplying the diurnal curve factor of 1.56 (between 7 pm and 9 pm) by 4.5 MGD. During these two hours the supply into the system from Wells A, C, and E is approximately 4.7 MGD but the

GAUGE TABLE

FOR

55'-0 DIAMETER 500M GALLON D.E. TANK (MADISON TANK)



Depth* Feet	Capacity Gallons	Depth* Feet	Capacity Gallons	Depth* Feet	Capacity Gallons
1	11,509	11	169,274	21	346,985
2	24,170	12	187,033	22	364,757
3	37,828	13	204,805	23	382,530
4	52,351	14	222,578	24	400,284
5	67,620	15	240,350	25	417,943
6	83,528	16	258,123	26	435,422
7	99,974	17	275,895	27	452,633
8	116,863	18	293,667	28	469,484
9	134,102	19	311,440	29	485,884
10	151,602	20	329,212	29.92	500,358

*Above Lower Capacity Line

PITTSBURGH-DES MOINES STEEL COMPANY

Figure 3.3

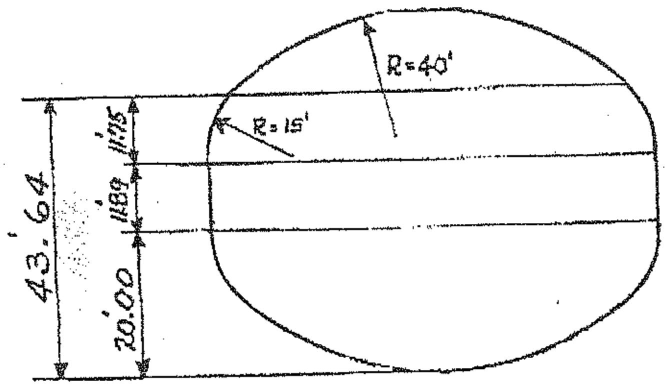
August 2, 1957

DB750-5

GAUGE TABLE

FOR

60'-0 DIAMETER 750M GALLON D.E. TANK (MIDWOOD TANK)



Depth	Capacity	Depth	Capacity	Depth	Capacity
1	922	16	197,541	31	513,800
2	3,697	17	218,115	32	534,964
3	8,249	18	238,975	33	556,879
4	14,539	19	259,995	34	577,112
5	22,522	20	281,139	35	597,916
6	32,149	21	302,290	36	618,459
7	43,375	22	323,441	37	638,597
8	56,151	23	344,592	38	658,227
9	70,399	24	365,743	39	677,271
10	85,929	25	386,894	40	695,593
11	102,561	26	408,045	41	713,074
12	120,137	27	429,196	42	729,603
13	138,539	28	450,347	43	744,982
14	157,661	29	471,498	43.64	754,150
15	177,332	30	492,649		

PITTSBURGH-DES MOINES STEEL COMPANY

Figure 3.4

usage rate is 7 MGD. Hence in two hours approximately 1,600 gpm for two hours (or 192,000 gallons) is required from storage.

- **Fire Protection** – a typical tank design includes additional storage for fire protection.

- **Emergency Reserve** - many tanks are designed to include an emergency reserve in the event of a major disruption of service from supply sources in the system. The Borough has emergency interconnections with three purveyors that can provide supply in the case of an emergency, reducing the potential emergency reserve the Borough requires.

The following table provides the equalization, fire protection, and emergency reserve volumes for the Madison tanks:

Storage Volume	Madison Tank	Midwood Tank	Totals
Equalization	100,000 gallons	110,000 gallons	210,000 gallons
Fire Protection	193,000 gallons	255,000 gallons	448,000 gallons
Emergency Reserve	207,000 gallons	385,000 gallons	592,000 gallons
Totals	500,000 gallons	750,000 gallons	1,250,000 gallons

From an operations standpoint, the tanks normally operate in the equalization range, thereby providing adequate storage remaining in the event of a fire.

Discussions with Water Department personnel indicate that additional storage in the system would improve operations of the system, and decrease annual pumping costs through the use of "off-peak" pumping. From an operations standpoint additional storage has several benefits:

- **Non-reliance on emergency interconnections** – although NJAWC can supply a substantial amount of water (explained in detail in following section of report), the supply is primarily a surface water supply from both the Passaic River and the Wanaque Reservoir. The surface water supply has very different water chemistry than the Borough's well water. Introduction of this water into the system can result in taste and odor complaints, and also in "red-water" problems. The "red-water" problems can be attributed both to changes in flow direction and higher than normal velocities in pipes near the interconnections, and also on a molecular level where the surface water aggressiveness can dissolve built-up corrosion products on the interior of unlined cast-iron pipe.

- **Provide additional equalization storage** – during summer months, the water department must continually cycle pumps on and off to maintain equalization storage. During summer periods of peak demand, water department personnel have indicated that unless they operate all wells simultaneously, tank levels will drop below the equalization range. Additional storage would increase the equalization volume, and improve overall system operations.

- **Reduce stress on piping systems** – as mentioned previously, the 10-inch diameter transmission mains installed near the Well A&B Treatment Plant with leadite joints have reportedly failed from the pressure increases associated with pumping all wells in the area at one time. Additional storage would reduce the need to pump these well supplies simultaneously.

- **Safety factor during unforeseen events** – Water Department personnel have indicated that in the past when telemetry was lost from the tanks, the tanks basically emptied since the wells did not come on based upon low tank level. In one case, Drew University called and indicated that their taps were dry at the higher building stories. Additional storage would not resolve this problem, but would result in pressures dropping very slowly instead of abruptly.

Many utilities practice off-peak pumping in order to reduce annual electrical costs. In general, electric utilities have different electric costs based upon the time of day pumping occurs. The Borough of Madison purchases electricity from Allegheny Power under the following rate structure:

Time of Day	Summer (Cost per KW-hour)	Non-Summer (Cost per KW-hour)
7:00 am to 11:00 pm (on peak)	$0.0858	$0.0421
11:00 pm to 7:00 am (off peak)	$0.0329	$0.0327

Summer Rates: June, July, August, September

Electric utilities also include a kilowatt demand charge to facilities, based typically upon the maximum kilowatt demand during on-peak demands during a given month. Madison's current contract with Allegheny Power includes a flat rate charge for kilowatt demand, and therefore, does not impact this off-peak pumping analysis.

The following table compares the approximate costs of pumping 1 million gallons (MG) of water from the various wells during peak and off-peak times for both summer and non-summer rates:

Electrical Pumping Cost Summary

	Summer		Non-Summer	
Location	**Cost to pump 1 MG (on peak)**	**Cost to pump 1 MG (off peak)**	**Cost to pump 1 MG (on peak)**	**Cost to pump 1 MG (off peak)**
Well A	$135	$52	$68	$51
Well B	$140	$54	$70	$52
Well C	$120	$46	$59	$45
Well D	$115	$44	$57	$44
Well E	$120	$46	$59	$45

Note: treatment plant pumping included in above table. Pumping efficiency estimated at 80%.

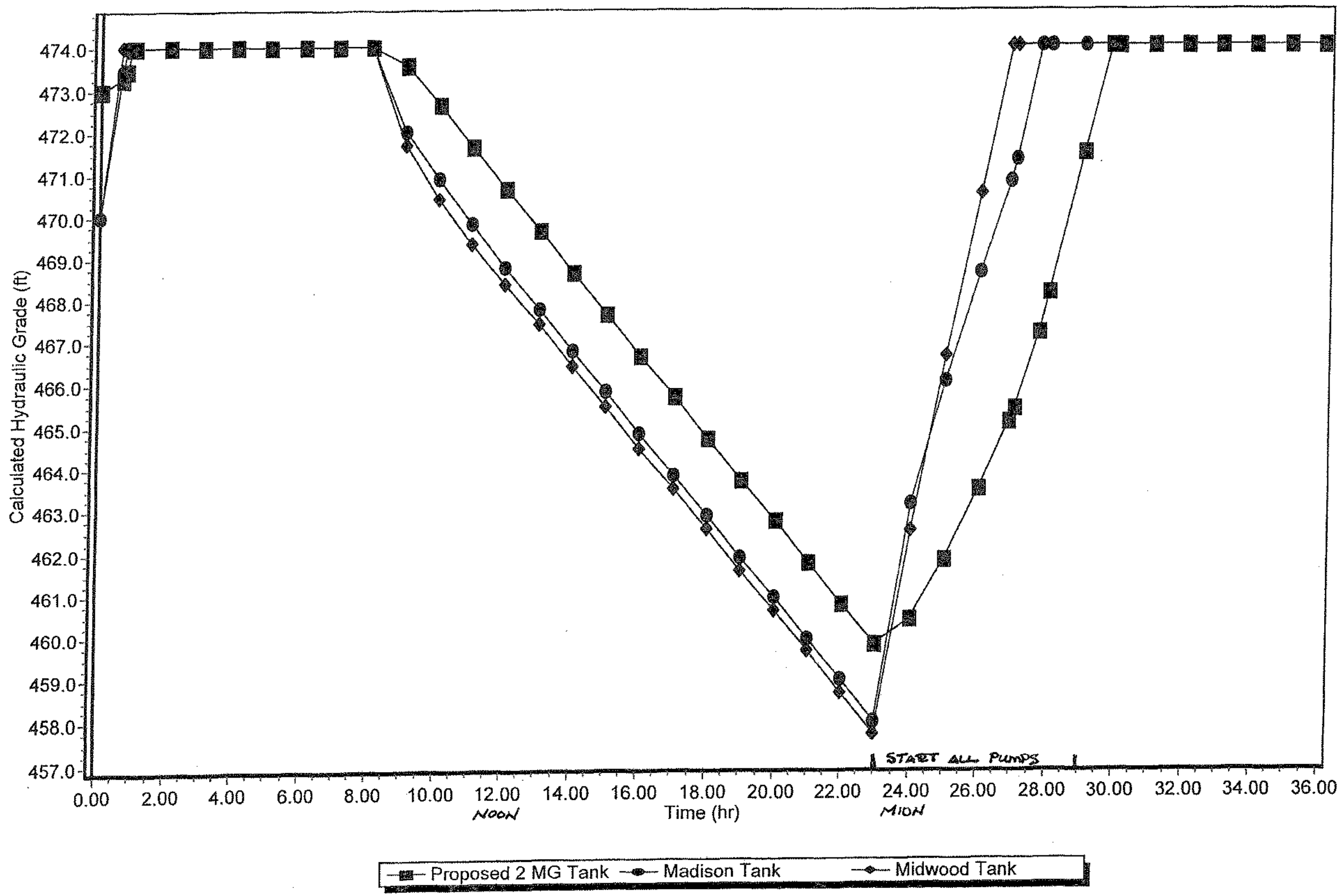
The ability to perform pumping during only the off-peak period is dependent upon having adequate storage, and under the conditions where water demands don't draw the tanks down too quickly. It is difficult to estimate exactly what operating conditions will support off-peak pumping, but a rough calculation was performed under the following criteria:

- During non-summer months (as defined by the electric utility), pumping could occur only during off-peak hours 80 percent of the time;
- During summer months, pumping could occur only during off-peak hours 40 percent of the time;
- A 15-foot drop in tank storage (from elevation 473 to 460 feet) could be tolerated on a daily basis; and
- Assuming that currently, pumping occurs evenly between off-peak and on-peak hours.

Figure 3-3 indicates the storage pattern for off-peak pumping during average day demand conditions, and indicates approximately 15 feet drop in storage over the course of the day before the tanks begin to recover.

Using the above criteria, it is estimated that the current utility electrical costs of $70,000/year could be reduced to approximately $50,000/year, for a savings of $20,000/year (30 percent savings). This can be compared to the

Tank Storage for Off-Peak Pumping (11 pm to 7 am) under Average Day Demand Conditions
Figure 3-3



estimated construction cost of $3 million, for a new 2 MG elevated tank. Assuming a 5% rate cost and a 20-year period, the annual cost to provide additional storage would be approximately $240,000/year.

4.0 Emergency Interconnection Capacity Analysis

The Borough of Madison maintains emergency interconnections with three outside purveyors as described in the following table:

Estimated Capacities of Emergency Interconnections

Location	Purveyor	Purveyor HGL	Diameter	Est. Capacity
Loantaka Way and Shunpike Road	NJAWC	617'	6-inch	1,000 gpm (to Madison)
Candlewood Drive and Shunpike Road	NJAWC	617'	6-inch	1,300 gpm (to Madison)
Noe Avenue and Shunpike Road	NJAWC	617'	6-inch	1,100 gpm (to Madison)
Brooklake Road	Florham Park	376'	4-inch	200 gpm (to Florham Park)
Ridgedale and Central Avenue	Florham Park	376'	4-inch	200 gpm (to Florham Park)
Greenwood Avenue	Florham Park	376'	4-inch	200 gpm (to Florham Park)
Madison Avenue near South Oak Circle	SMCMUA	523'	4-inch	200 gpm (to Madison)

The three (3) New Jersey-American Water Company (NJAWC) emergency interconnections are all located along Shunpike Road on the Border of Chatham Township and the Borough of Madison, and are connected to NJAWC's Baltusrol Gradient System (617 Gradient). NJAWC owns and operates the Chatham Pump Station located near the intersection of Shunpike Road and Loantaka Way, that is operated almost continuously and pumps into a 36-inch diameter transmission main, that in turn feeds a 12-inch main on Shunpike Road.

The hydraulic gradeline of NJAWC's system is in excess of 600 feet, and therefore provides significant head to transfer water into the Borough's system, which has a gradeline of approximately 470 feet. It is noted that the use of these interconnections requires the operation and throttling of manual valves to decrease pressure and control flow into the Borough's system. Refer to Appendix A for schematics and location diagrams of all the interconnections. It is recommended that the Borough install pressure reducing valves in these chambers as a safeguard of over pressurizing the Borough's system when used during emergencies.

Hydraulic modeling was performed to determine the capacity of the NJAWC interconnections, and included a pressure-reducing valve to maintain no greater than a gradeline of 480 to 490 feet to the Borough. Under EPS for average day demands, the interconnections each operated between 200 to 700 gpm to supply the Borough with all Borough wells out-of-service. The analysis performed for average day demand conditions indicates the ability to maintain adequate storage in the Borough's tanks, and adequate pressure in the system.

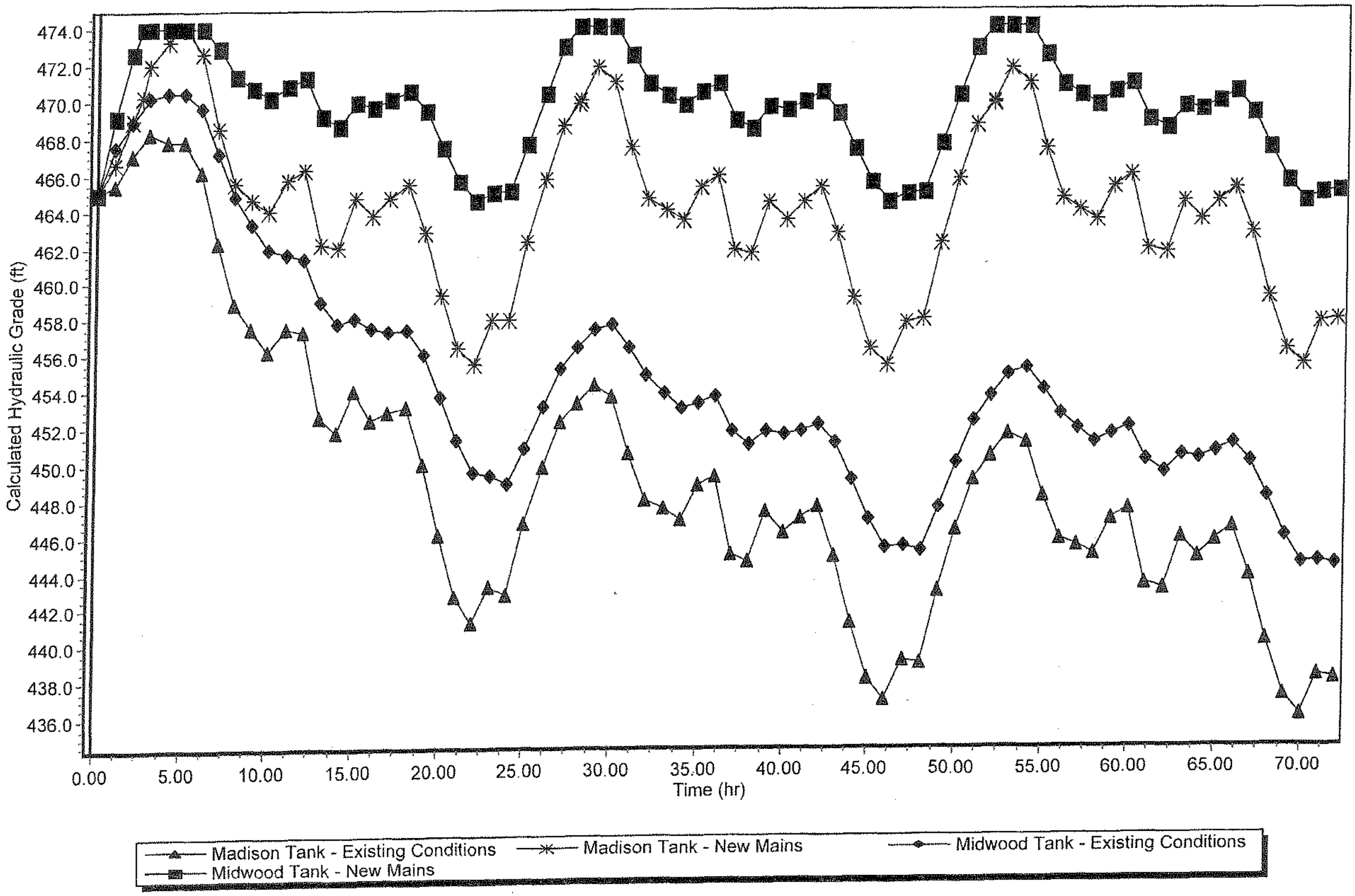
However, under maximum day demand conditions, the EPS indicated a gradual decline in tank storage over a three-day period, as the system balanced itself with the NJAWC supply. Reviewing the water main infrastructure, it is noted that the existing 4-inch diameter mains along Garfield Avenue, Green Village Road, and Green Avenue restrict flow from NJAWC into the Borough, and produce high main velocities within the Borough's system (which can lead to water quality complaints). Under the maximum day demand conditions, the NJAWC interconnections each delivered in excess of 1,000 gpm as indicated in the above table.

It is recommended that the 4-inch mains in these roads be replaced with 8-inch mains in the future. This will both increase emergency interconnection capacity during maximum day demand conditions, and also generally improve pressure, and fire protection capacity. In addition, it will allow the gradeline set from NJAWC to be slightly reduced, which will maintain pressures near the interconnections near normal during emergency transfers.

Figure 4-1 compares the tank levels during an emergency transfer from NJAWC under maximum day demand conditions, with and without the 4-inch main replacement described above. The figure indicates that, for the same hydraulic gradeline from NJAWC of approximately 480 feet, the new mains improve hydraulics and maintain storage in the system over the course of several days of high demands, whereas there is a loss of storage with the 4-inch mains not replaced.

The interconnection with Southeast Morris County Municipal Utilities Authority is a small 4-inch diameter valved interconnection of limited capacity. The interconnections with Florham Park are one-way interconnections to supply Florham Park with no capacity to the Borough.

Comparison of Tank Levels During Maximum Day Demands, Emergency Transfer from NJAWC
With and Without Main Replacement
Figure 4-1



5.0 Review of System Transmission

The Borough's water system is comprised of a network of 10-inch and 12-inch diameter transmission mains between sources of supply (wells) and the two storage tanks. A review of the network indicates substantial redundancy, and a main break on any given transmission main will not result in an interruption of the supply of water.

As discussed in the previous section, there are some existing four-inch diameter mains in the vicinity of the NJAWC interconnections that should be replaced. In general, 4-inch diameter mains are substandard for today's water systems, and utilities have included their replacement in their ongoing capital improvements program based upon available funding.

There is also a 4-inch diameter main on Division Road between Woodland Road and Main Street, that if replaced, would slightly improve hydraulics and redundancy of transmission associated with pumping from Wells A, B, and E.

The following table provides a list of the priority 4-inch diameter water main replacement:

Street	Location	Length (ft.)	Main Dia. (in)	Estimated Cost
Green Village Rd	From Shunpike Rd. to Douglas Ave	1,600	8	$120,000
Green Avenue	From Shunpike Rd. to Midwood Terrace	2,400	8	$180,000
Garfield Avenue	From Green Village Rd. to Woodland Rd	4,000	8	$300,000
Division Road	From Main St. to Woodland Road	1,200	8	$90,000
			Totals	**$690,000**

It is also recommended that the Borough inventory the location of all transmission main in the system that has leadite joints, and include the replacement of these mains, that are prone to failure, in the annual capital improvements programs based upon available funding.

6.0 Review of Water System Operation

Wells are turned on and off based upon tank levels using a basic Supervisory Control and Data Acquisition (SCADA) system. Wells A, B, and E are controlled by the level in the Midwood Tank, and Wells C and D are controlled by the level in the Madison Tank. Under normal operating conditions Wells A, C, and E are operated, and Well B is used for peaking.

The Borough water system utilizes lease line phone communications between the tanks, wells and utility building. An old, ATCOM programmable logic controller (PLC) is used to communicate well start/stop operation based upon tank level. Tank level and well discharge is recorded on chart recorders at the utility building.

In the event that there is a tank overflow or empty tank, or a general alarm from the Well A and B VOC Removal Facility, the alarm is communicated to the utility building, and an auto-dialer calls the local police with a general alarm.

At Wells C, D, and E, should a well pump malfunction or fail to occur, there is no alarm to the utility building. If either Well A or B fails, it would eventually be noticed through a low clearwell level at the VOC Removal Facility which would result in a general alarm.

Today's SCADA technologies are relatively inexpensive as compared to even a few years ago, and provide the ability to collect all needed information from remote facilities (flow, pressure, alarms, equipment runtime, etc.) that can be viewed in real-time or used to develop an historical database. SCADA systems can also be used to relay information from security devices (e.g., intrusion detection, motion detection). Using SCADA, the specific alarm from a facility can be determined remotely (even from home), which improves operation of the system.

It is recommended that the Borough upgrade the existing SCADA system to: 1) record additional information from facilities, 2) provide specific alarms from equipment and processes, 3) build a historical database or system operational data, and 4) provide operators with improved decision making tools. Low cost systems are available using radio system communication that can improve reliability, and eliminate the need for the monthly expense of leased phone lines.

7.0 Summary and Recommendations

The Borough's water system includes five water supply wells, with one currently out-of-service the Borough is moving forward with treatment to return Well D to active service. In addition, there are three high capacity emergency interconnections with NJAWC. There is a total of 1.25 million gallons of water storage in two elevated storage tanks. In general, there is adequate supply and capacity to meet system demands.

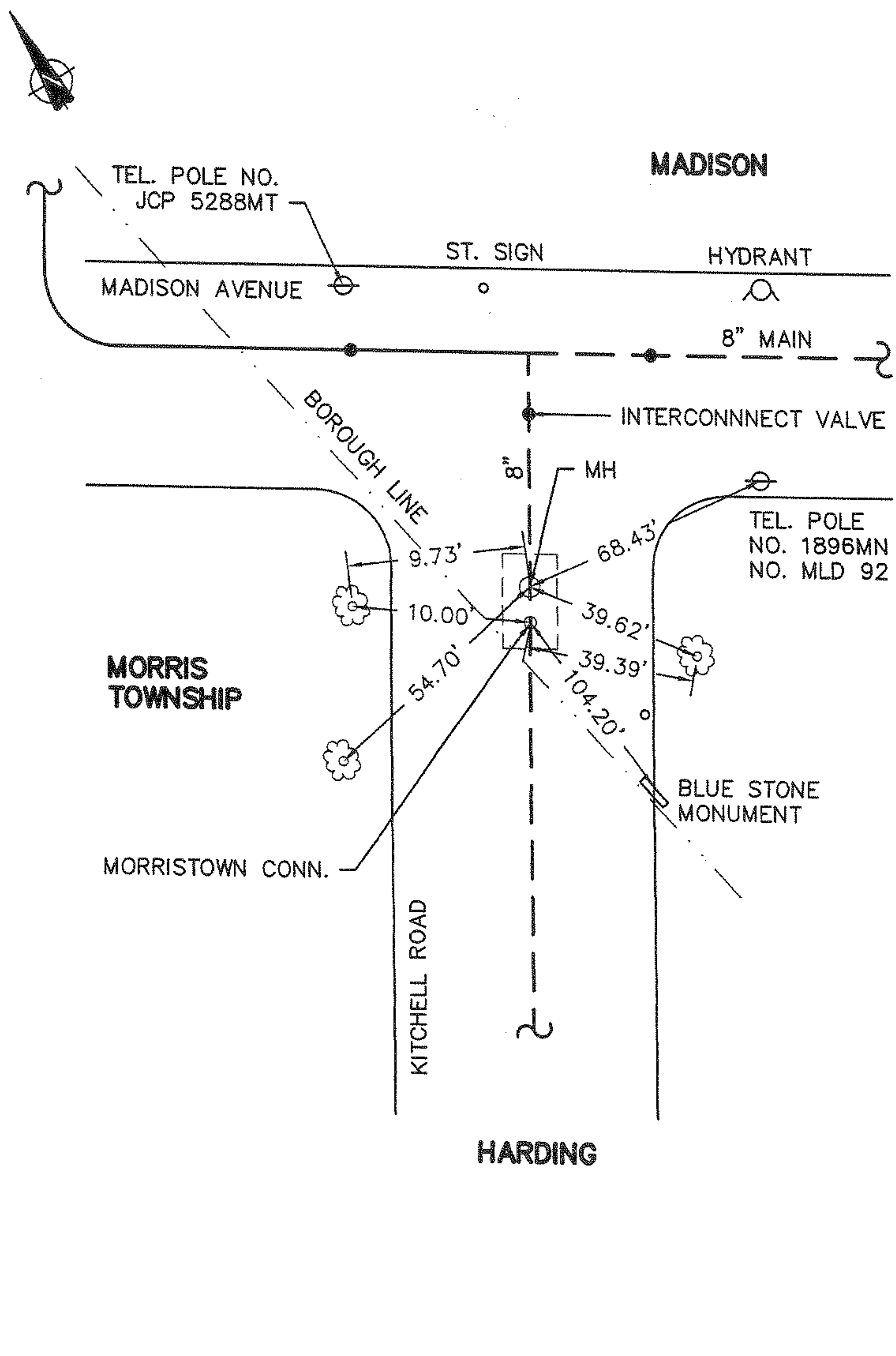
The main result of the analysis of critical system components indicates that Well D is a valuable source of supply that needs to be returned to service. This additional supply will insure adequate supply (solely from Borough sources) and adequate fire protection for the emergency scenarios studied.

The analyses also yielded additional observations and recommendations summarized as follows:

- Additional fuel storage for standby power facilities, of at least 12 hours of operation, is recommended for Wells C, D, and E.
- Existing transmission piping with leadite joints that is prone to failure is recommended for replacement under the capital improvements program.
- Priority replacement of 4-inch diameter transmission main is estimated at a construction cost of $690,000
- It is recommended that the Borough install pressure reducing valves in the valve chambers to prevent potential over pressurization of the Borough's system
- Additional tank storage would improve operations and redundancy, including electrical savings utilizing off-peak pumping, but must be weighed against the capital cost estimated at $3 million for 2 MG of storage.
- It is recommended that the existing SCADA system be upgraded to improve system operation and reliability.

APPENDIX A

Emergency Interconnection



Hatch Mott MacDonald

Certificate No. 24GA28075000

27 Bleeker Street
Millburn, New Jersey 07041

BOROUGH OF MADISON

EMERGENCY INTERCONNECTION
SMCMUA

MADISON AND KITCHELL AVENUE

Designed	Drawn	Checked	Approved	Date
	IER			

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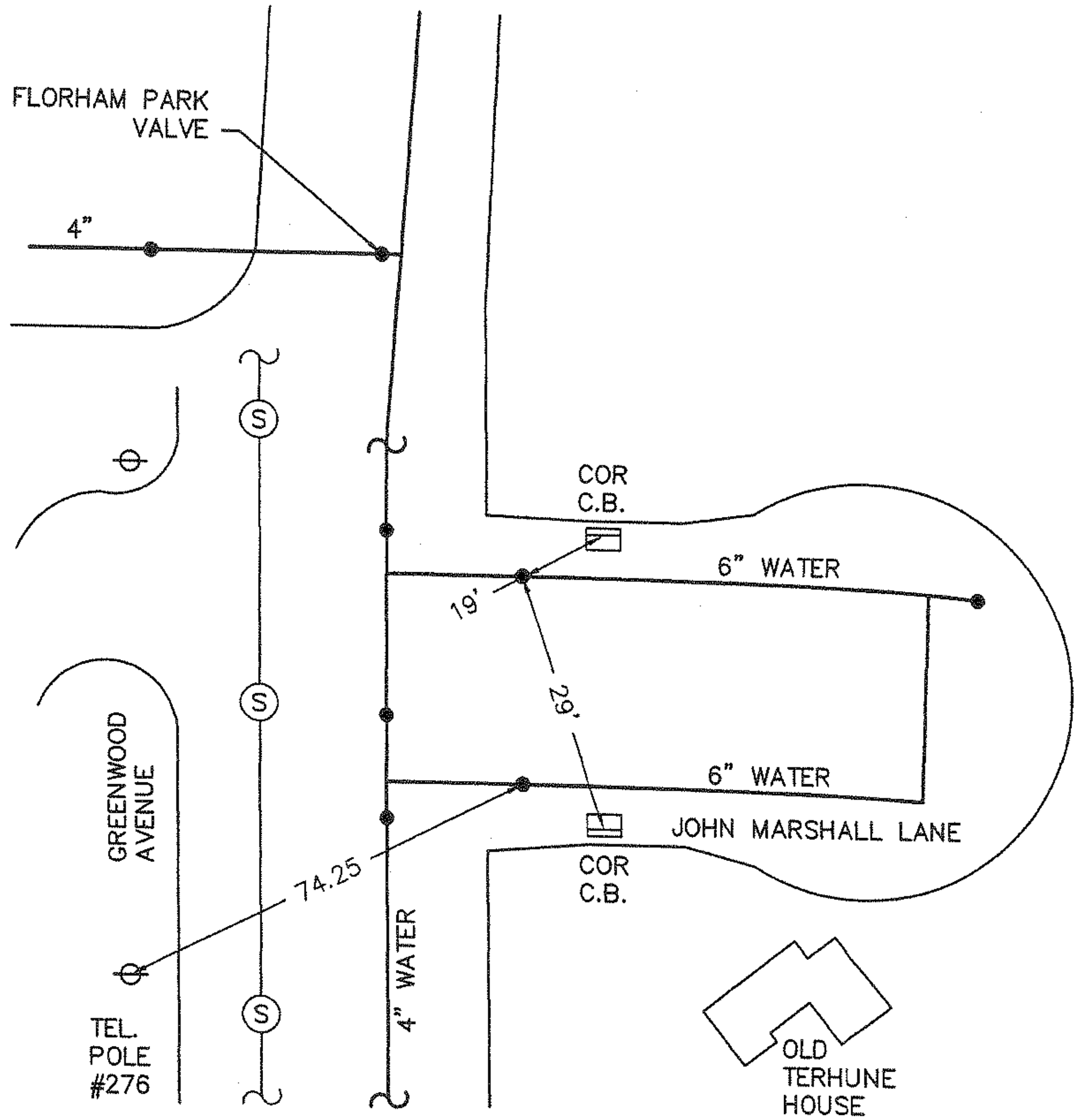

Hatch Mott MacDonald
Certificate No. 24GA28075000
27 Bleeker Street
Millburn, New Jersey 07041

BOROUGH OF MADISON

EMERGENCY INTERCONNECTION
NORTH FLORHAM PARK

GREENWOOD AVENUE AND JOHN MARSHALL LANE

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	IER			

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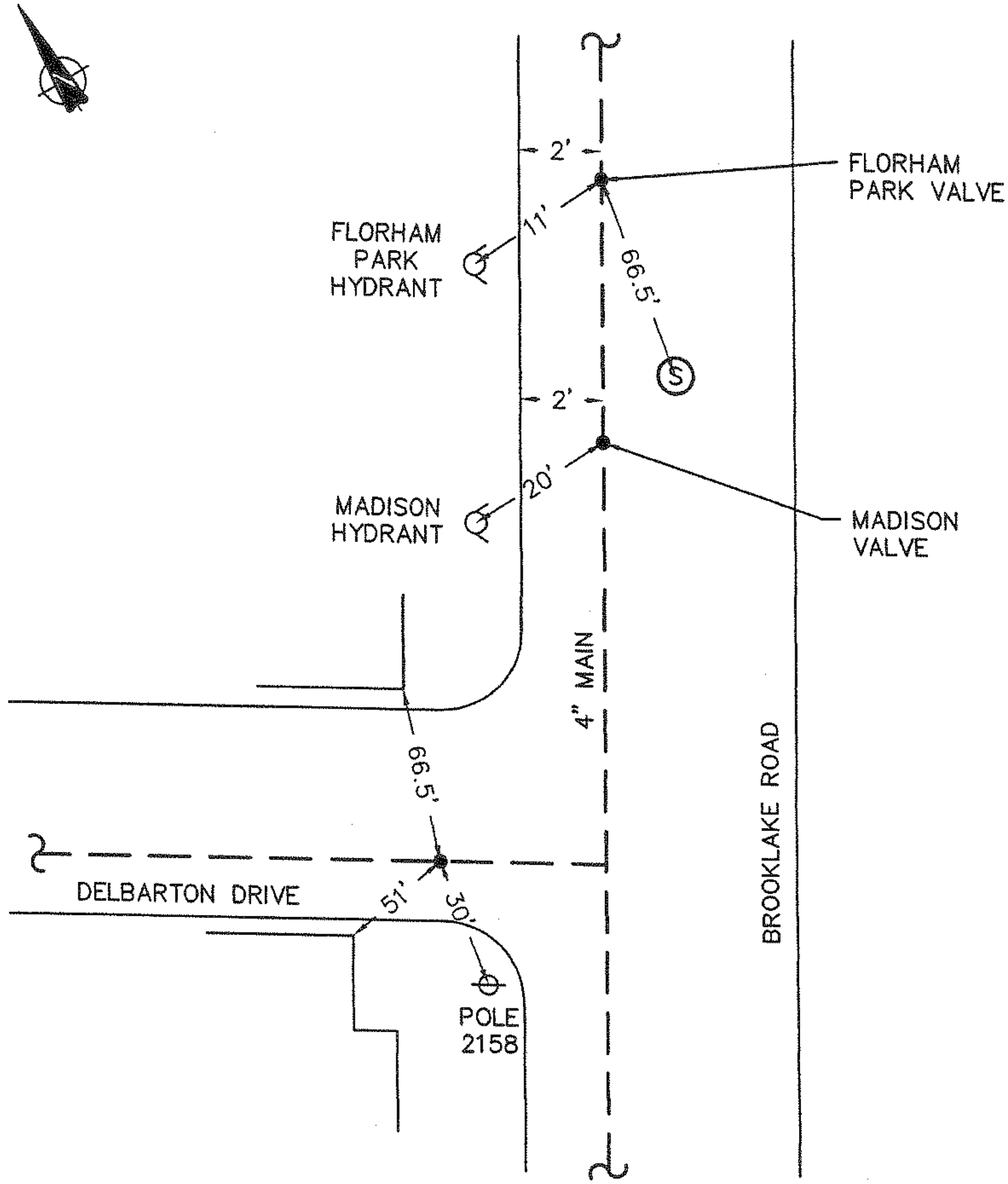

Hatch Mott MacDonald
Certificate No. 24GA28075000
27 Bleeker Street
Millburn, New Jersey 07041

BOROUGH OF MADISON

EMERGENCY INTERCONNECTION
FLORHAM PARK

DELBARTON DRIVE AND BROOKLAKE ROAD

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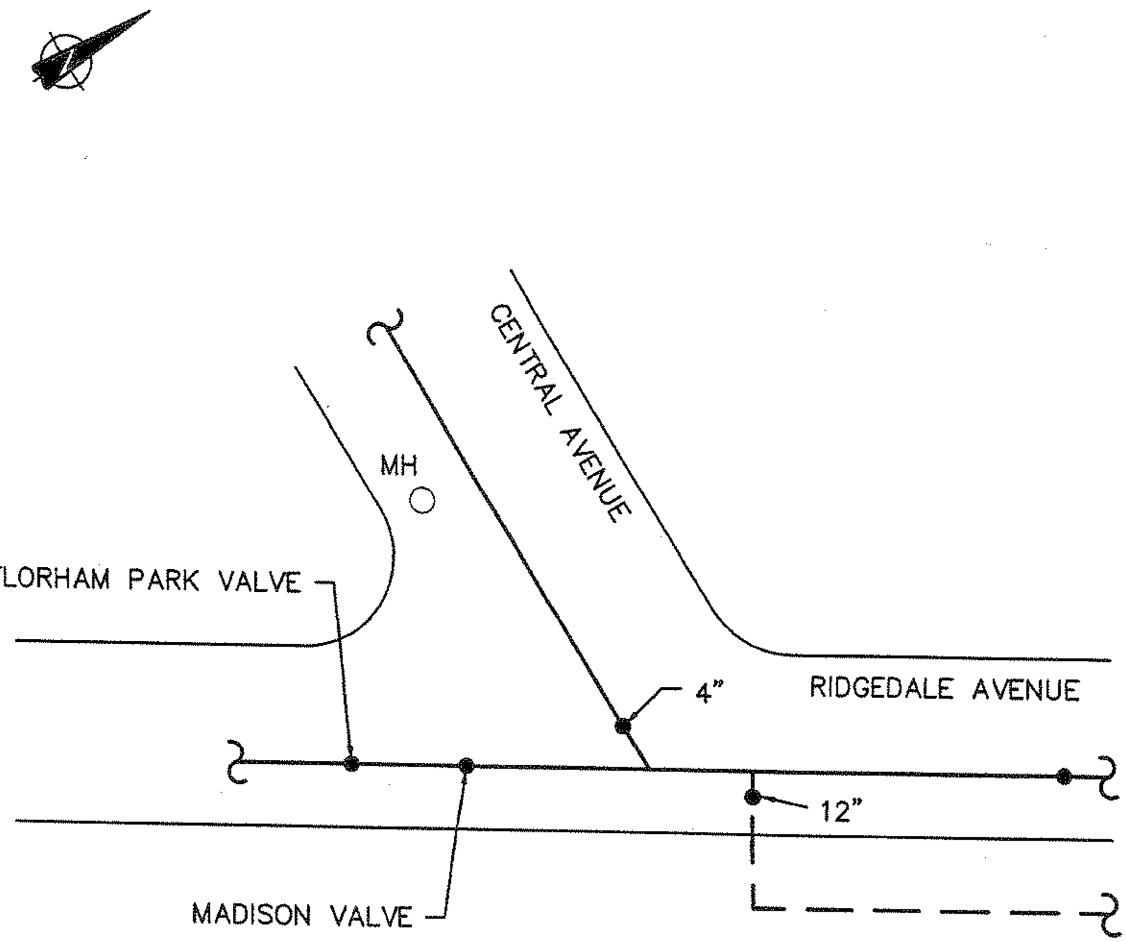

Hatch Mott MacDonald
Certificate No. 24GA28075000
27 Bleeker Street
Millburn, New Jersey 07041

BOROUGH OF MADISON

EMERGENCY INTERCONNECTION
FLORHAM PARK

RIDGEDALE AVENUE AND CENTRAL AVENUE

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	IER			

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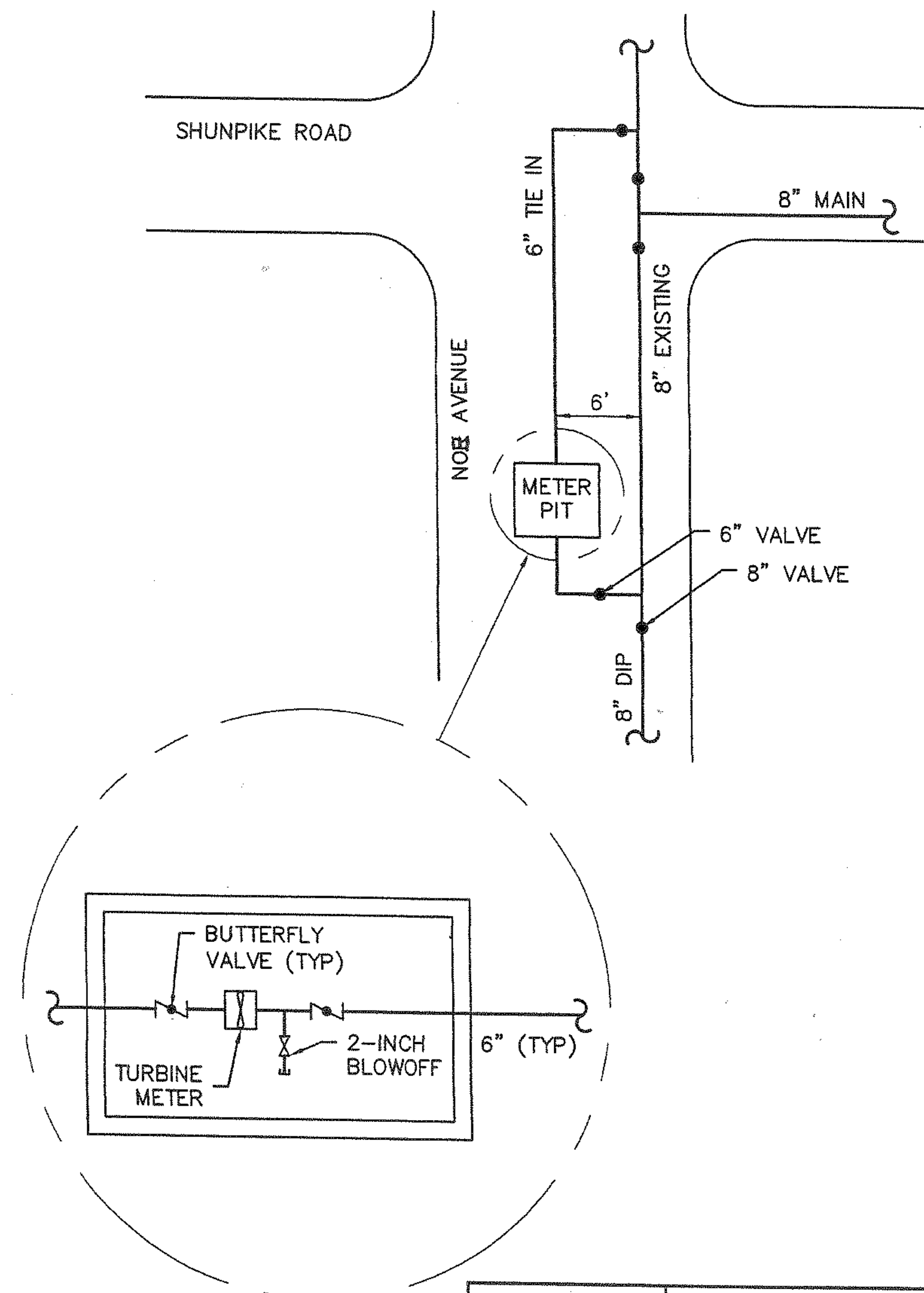

Hatch Mott MacDonald
Certificate No. 24GA28075000

27 Bleeker Street
Millburn, New Jersey 07041

BOROUGH OF MADISON

EMERGENCY INTERCONNECTION
NJAWC

SHUNPIKE ROAD AND NOR AVENUE

Designed	Drawn	Checked	Approved	Date
	IER			

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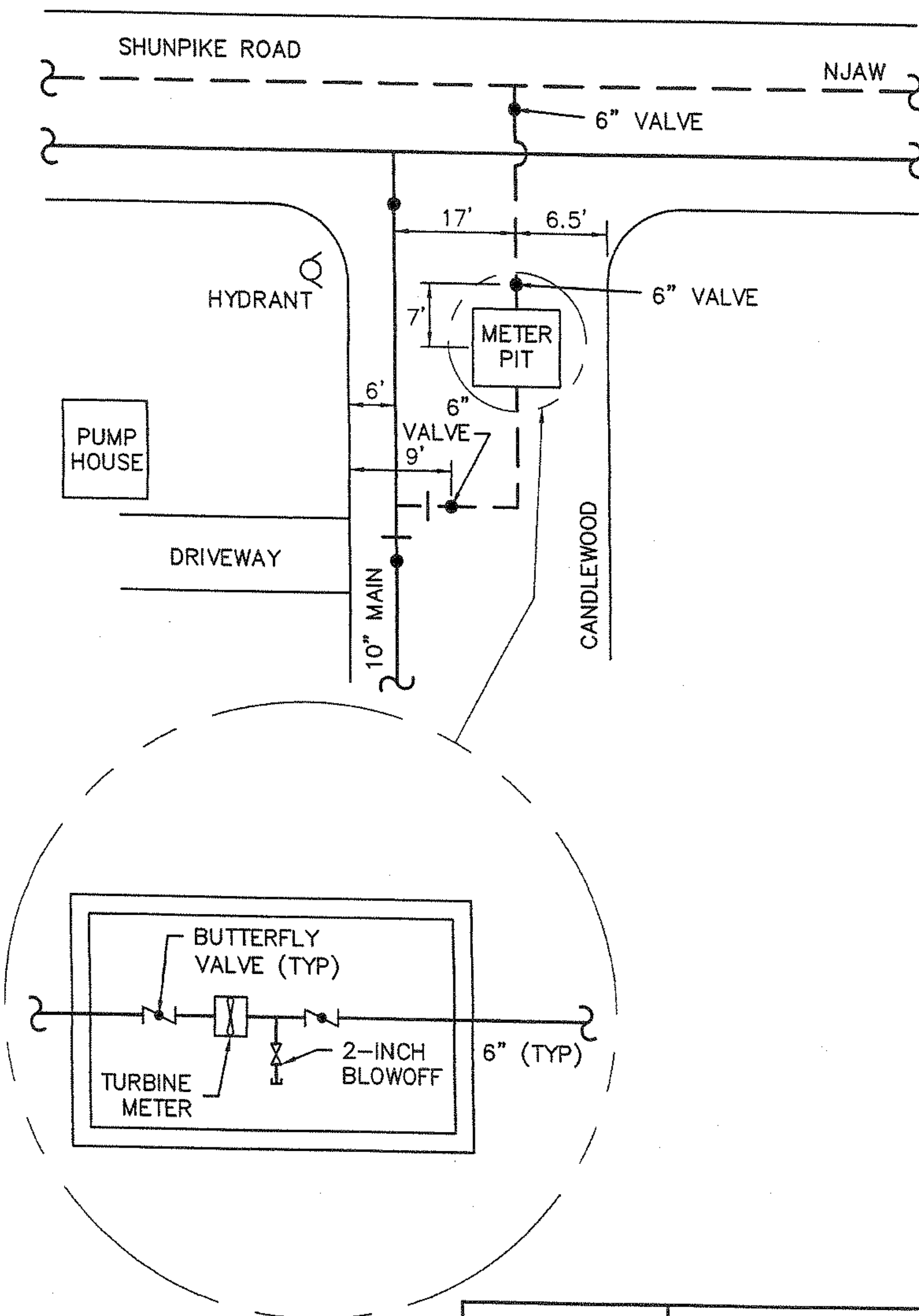

Hatch Mott MacDonald
Certificate No. 24GA28075000
27 Bleeker Street
Millburn, New Jersey 07041

BOROUGH OF MADISON

EMERGENCY INTERCONNECTION
NJAWC

SHUNPIKE ROAD AND CANDLEWOOD

Designed	Drawn	Checked	Approved	Date
	IER			

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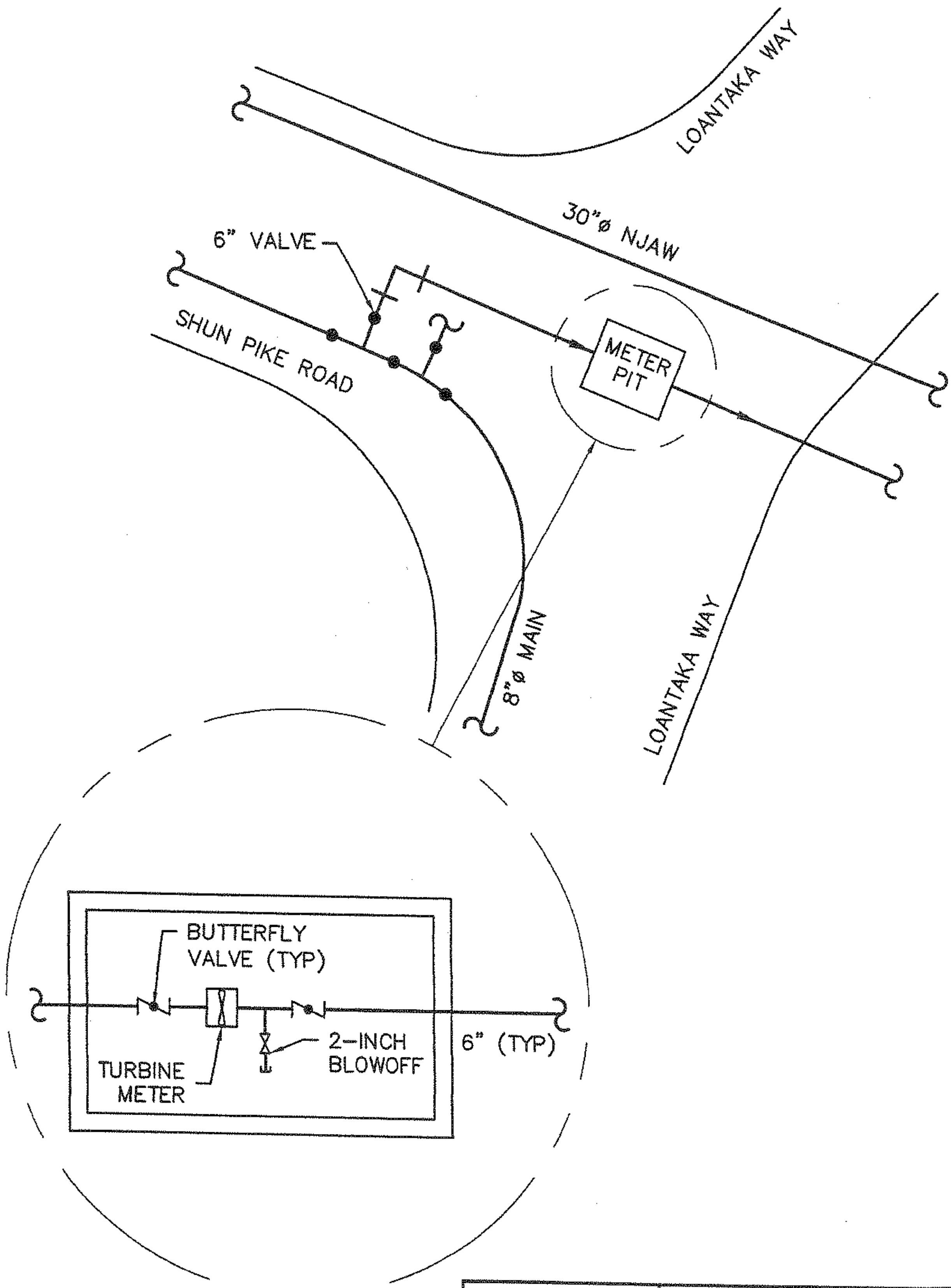

Hatch Mott MacDonald

Certificate No. 24GA28075000

27 Bleeker Street
Millburn, New Jersey 07041

BOROUGH OF MADISON

EMERGENCY INTERCONNECTION
NJAWC

SHUNPIKE ROAD AND LOANTAKA WAY

Designed	Drawn	Checked	Approved	Date
	IER			

P:\207484\DWG\METERPIT@LOANTAKA&SHUNPIKE.dwg 10/15/03 9:05 am

Notes :