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2006-01-0155

WATER DISTRIBUTION SYSTEM ANALYSIS AND MASTER PLAN FOR THE CITY OF TOMBSTONE, ARIZONA

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F0391, EHB-17

CELLA BARR ASSOCIATES
2075 North Sixth Avenue
Tucson, Arizona 85705

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INTRODUCTION

The existing facilities which produce, pump, store, and distribute water to the City of Tombstone are of widely varying age and condition. Some components of the water system were constructed in the 1880's and are still in use. Many additions and improvements have been made to the system during the past 100 years. While the system is generally capable of delivering adequate quantities of potable water for domestic use and limited fire flows, there are some deficiencies which can and should be remedied. Additional improvements can be made to provide better overall system reliability and increased fire flows at selected areas of the town.

The purpose of this report is to characterize and inventory the existing water supply facilities; identify and detail system deficiencies; and, describe the improvements which have been developed for the system.

SYSTEM DEMANDS AND DEFICIENCIES

Current demand on the system has been estimated at 600,000 gallons per peak day and 250,000 gallons per average day.

The existing distribution system in the business district of the city is inadequate from the standpoint of fire protection. This represents a significant risk to the economic health of the community and comprises a major system deficiency. Insufficient "looping" of the pipe network, the existing small diameter piping and undersized fire hydrants are the specific problems. Available fire flow is insufficient in most locations within the central section of the city, for the same reasons as for the business district. Required and available fire flows for a number of locations are tabulated in the appendix to this report.

The absence of functional chlorination facilities represents another system deficiency. The 100,000-gallon storage tank is equipped with a chlorinator, however, the feed line is improperly installed. Another chlorinator is located at the valve vault in the seven-inch line from the large reservoir. However, this unit is not in service. No other storage facilities (or wells) are equipped with chlorination equipment.

The general deterioration and disrepair of the system limits its utility and efficiency and should be corrected. Specific deficiencies include:

The pumps, piping and valves in the valve vault in the seven-inch line from the reservoir are completely dilapidated and non-functional, now submerged in several feet of water;

The 100,000-gallon storage tank and appurtenances are in a state of general disrepair;

The booster pump at well site #3 is improperly sized for the system and produces excessive (and potentially damaging) pressures;

The valve vaults at the pressure reducing stations are in need of replacement and are improperly covered;

A backflow prevention device is not installed on the potable water line at the sewage treatment plant.

EXISTING EQUIPMENT INVENTORY

Water is supplied to the storage and distribution system by three drilled wells located within the city and seven artesian springs, located 25 miles to the south in the Huachuca Mountains, via a historic seven-inch diameter rolled steel pipe aqueduct. The wells are from 10 to 40 years old, the spring catchments and aqueduct are over 100 years old. The total estimated rate of supply from the wells is currently 800 gallons per minute (gpm). The rate of supply from the springs has averaged approximately 725 gpm in the past, although the current rate of supply is unknown.

Considerable water storage is provided by a 1.1 million gallon concrete reservoir, located south of the city, which is filled by the aqueduct from the springs. In addition, a ground level storage tank of 100,000-gallon capacity is located on a hill at the south edge of the city and a total of three smaller (25,000 gallons each) storage tanks are located at two of the well sites.

The vast majority of the system's service area is located within a single pressure zone. The low pressure boundary is roughly at the 4,600 foot elevation contour, to the south of the city, and the high pressure boundary is roughly at the 4,495 foot elevation contour, generally north of the city. These boundaries are established by the system highwater as defined by the elevation of the 100,000 gallon storage tank (mean water surface elevation = 4689). Services in the extreme northwest portion of the service area are located below the 4,495 foot elevation contour and pressures at these services are moderated by means of pressure-reducing valves. Refer to Figure 1 for a schematic map of the system and Figure 2 for a map delineating the zone boundaries.

Water is delivered to the system from the 100,000-gallon storage tank by gravity flow (no pressurization is required due to the elevation of the tank). Water is delivered from the smaller well site tanks by means of booster pumps.

The distribution system consists of piping of various materials, sizes, condition and age. The central portion of the city contains primarily older steel pipe of two-, three-, and five-inch diameters. Some six-inch diameter asbestos cement (AC) pipe has more recently been installed in this area (in Fremont Street, Bruce Street and North Street). Other portions of the distribution system (primarily to the north, east and west) have been installed more recently and consist of mostly six-inch diameter AC pipe.

Specific data for the water supply system (wells, booster pumps and storage tanks) have been collected and are tabulated in Appendix A of this report.

2. Construct new 300,000 gallon storage tank at site of existing 100,000 gallon tank. (See Figure 3, Sheet 5.)

3. Install new fire hydrants (in conjunction with new piping) at appropriate locations within the central business district. Approximately 12 new hydrants (capable of discharging high fire flow rates) should be installed.

The expansion and refurbishment of the chlorination facilities for the water system is recommended. These improvements will improve the quality of the water delivered and reduce the risk of disease from water-borne pathogens. Specifically, the following improvements to the chlorination facilities are recommended:

1. Install chlorinator at the 1 MG reservoir;

2. Re-install chlorine injection line deeper within the 100,000 gallon storage tank and generally refurbish the chlorinator and housing facilties;

3. Install chlorination facilities at each of the three supply wells.

Improved system reliability and a reduction in future operating and maintenance expenses can be accomplished through implementation of the following system improvements:

1. Replace booster pump at Well #3 with a properly specified unit.

2. Install automatic controls for the natural gas-powered engine at Well #2.

3. Repair or replace the valve vault at the two pressure reducing stations.

4. Refurbish the 100,000 gallon storage tank and appurtenances (install screen cover, install safety climber, repaint tank, install overflow pipe, refurbish chlorination shed).

5. Refurbish valve vault in the seven-inch line from the 1 MG reservoir. Booster pump should be replaced, valves and connection piping should also be replaced. Install new meter.

6. Install a target on 1 MG reservoir to permit water level readings from city.

7. Attempt to reactivate seven-inch line to 100,000 gallon storage tank from 1 MG reservoir.

8. Repair roof panels on 1 MG reservoir.

RECOMMENDED SYSTEM IMPROVEMENTS

A master plan for system improvements has been developed to achieve the following goals:

1. Improve fire flow capability for the central business district;

2. Improve bacteriological water quality;

3. Reduce operating and maintenance expenses and improve system reliability.

The improvement in fire flow to the central business district can be accomplished through augmentation and expansion of the existing water supply piping in the area, construction of additional water storage facilities and installation of larger fire hydrants. Specifically, the improvements are as follows:

1. Construct new distribution piping -

Location	Pipe Size (in.)	Length (ft.)
Existing 100,000 gallon storage tank site to existing five-inch line at Allen and Sixth Street	12	2,350
Toughnut Street from Second Street to Sixth Street	12	1,510
Second Street from Toughnut Street to Allen Street	8	300
Third Street from Toughnut Street to Allen Street	8	300
Fourth Street from Toughnut Street to Allen Street	8	300
Amm Street from Allen Street to Fremont Street	6	350
Sixth Street from North Street to Allen Street	6	2,300

FIGURE 1 IS LOCATED IN THE

MAP POCKET INSIDE THE BACK

COVER OF THIS REPORT

9. Install a backflow prevention device at the sewage treatement plant water service.

Implementation of the system improvements described above will dramatically improve the ability of the City of Tombstone's water system to provide safe, potable water for domestic use as well as provide water in sufficient quantities for fire protection of the central business district.

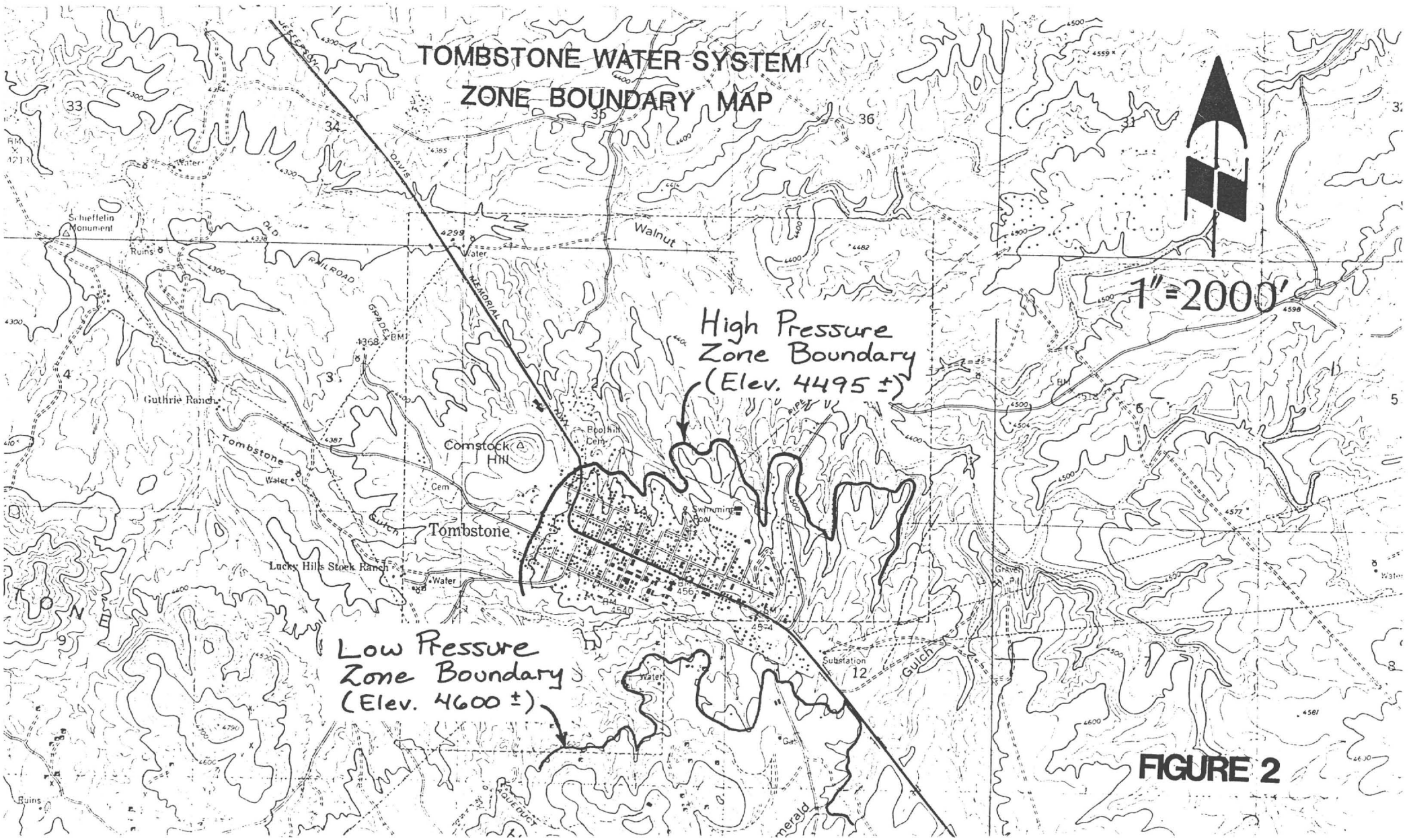
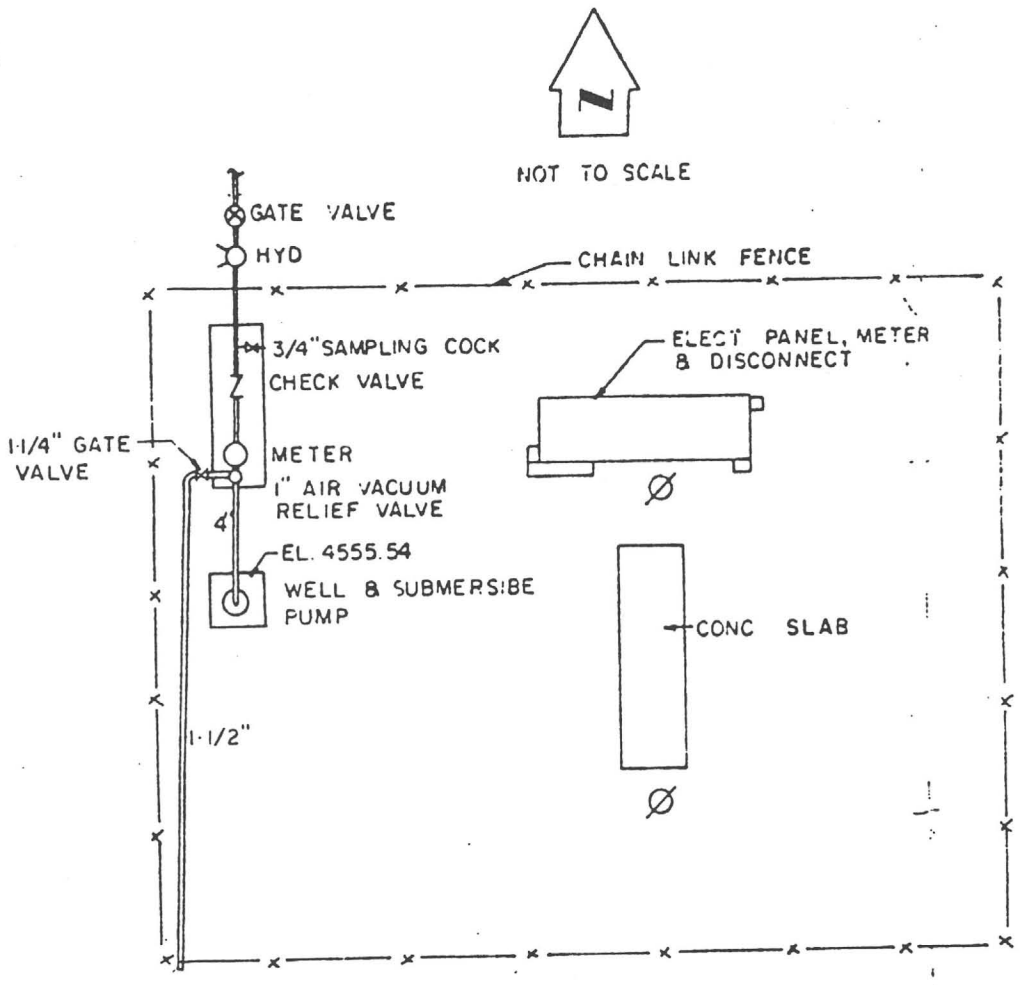

TOMBSTONE WATER SYSTEM
ZONE BOUNDARY MAP
1" = 2000'
High Pressure
Zone Boundary
(Elev. 4495 ±)
Low Pressure
Zone Boundary
(Elev. 4600 ±)
Tombstone
Comstock Hill
Guthrie Ranch
Lucky Hills Stock Ranch
Schieffelin Monument
Walnut
Gulch
Substation
Swimming Pool
Boothill Cem
Cem
Ruins
Water
Gravel Pit
Aqueduct
Jefferson Davis Memorial Hwy
Old Railroad Grade

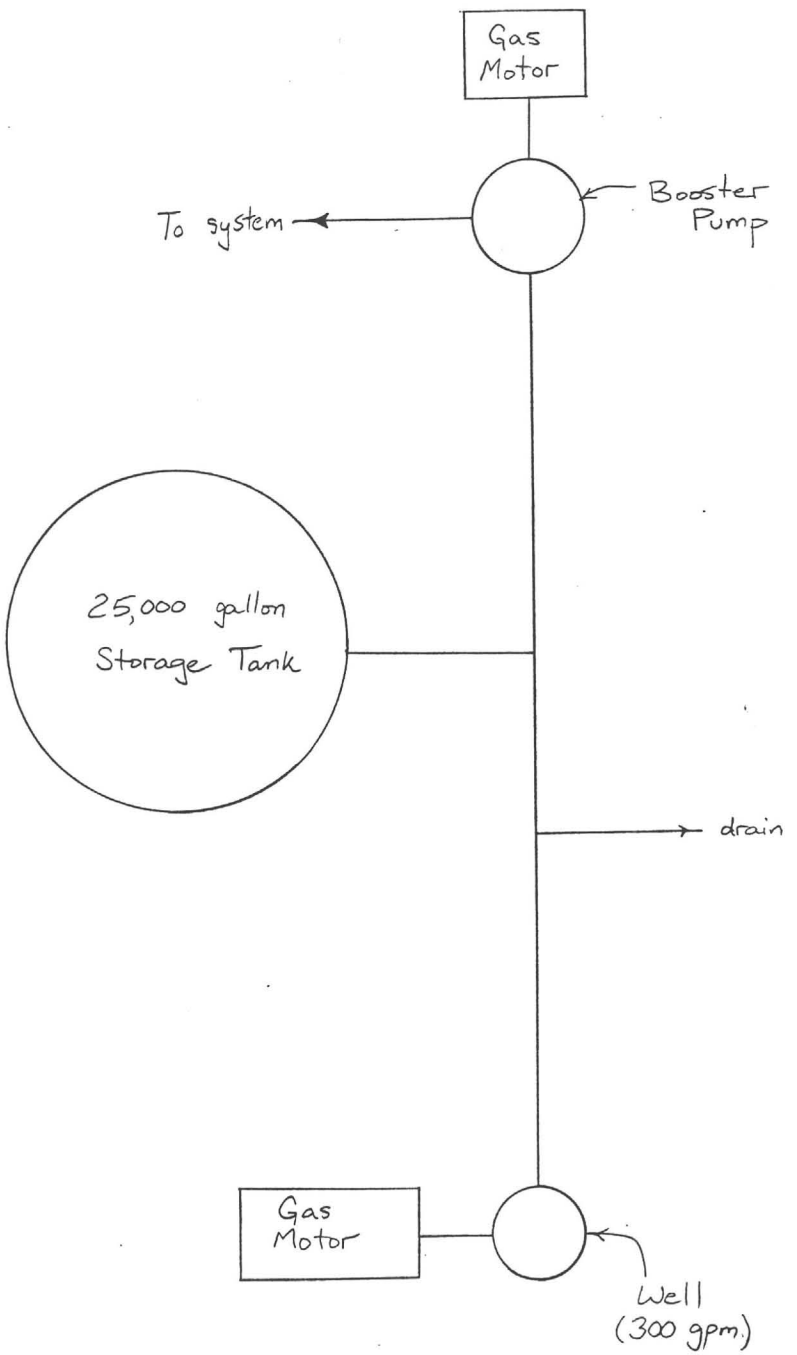
FIGURE 2



WELL NO. 1

FIGURE 3

SHEET 1 OF 6



WELL #2

NTS

FIGURE 3
SHEET 2 OF 6

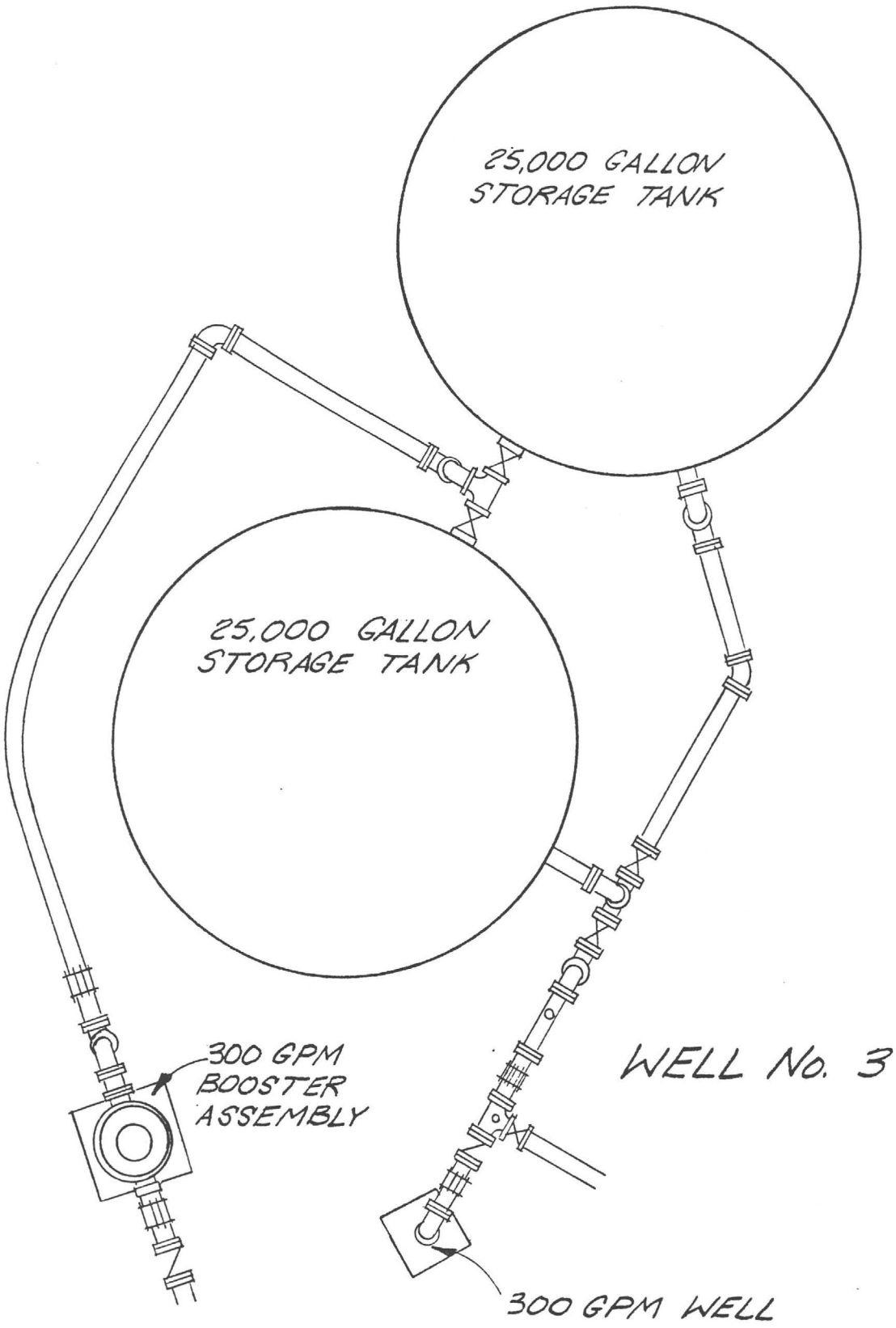


FIGURE 3
SHEET 3 OF 6

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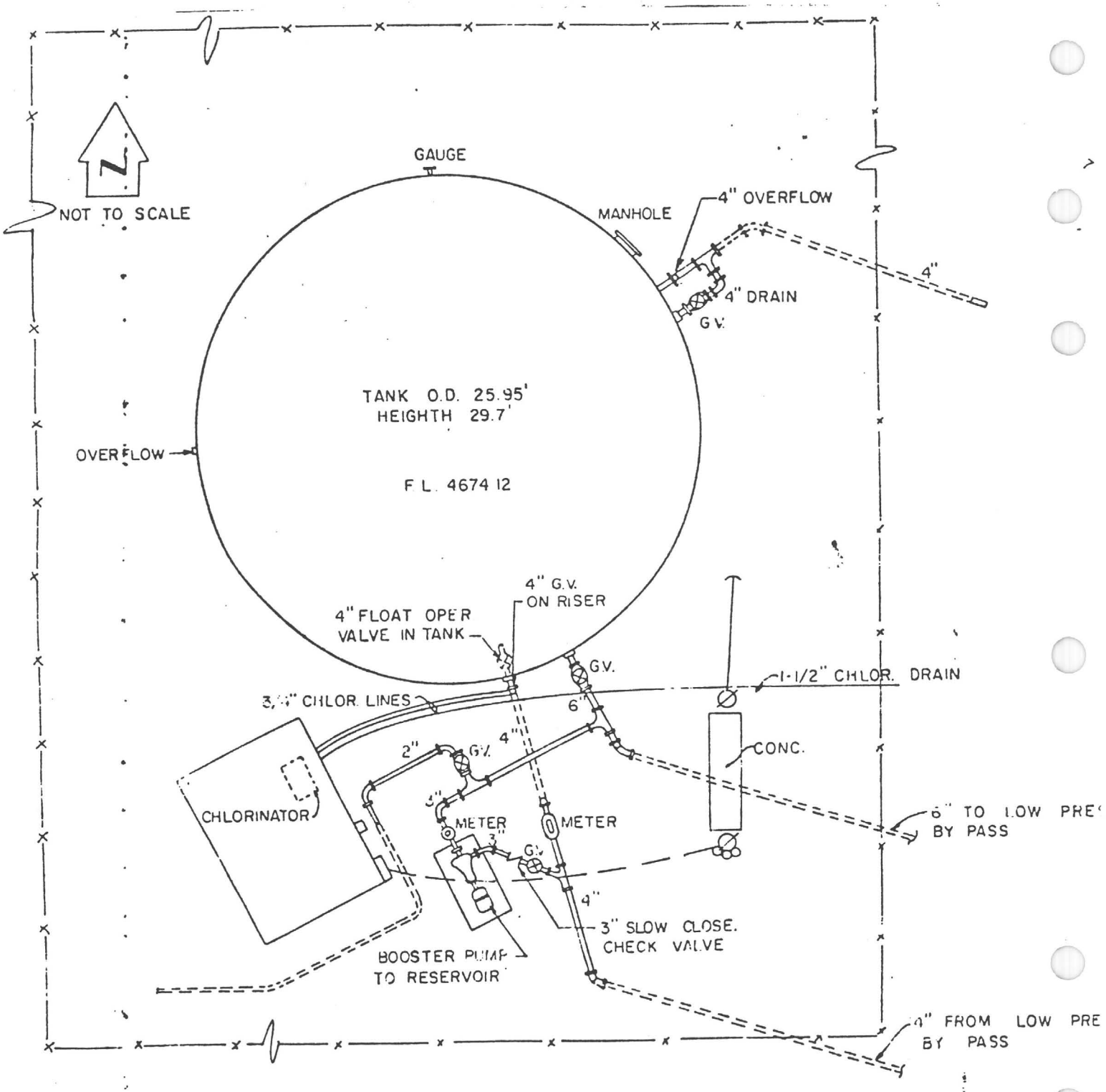
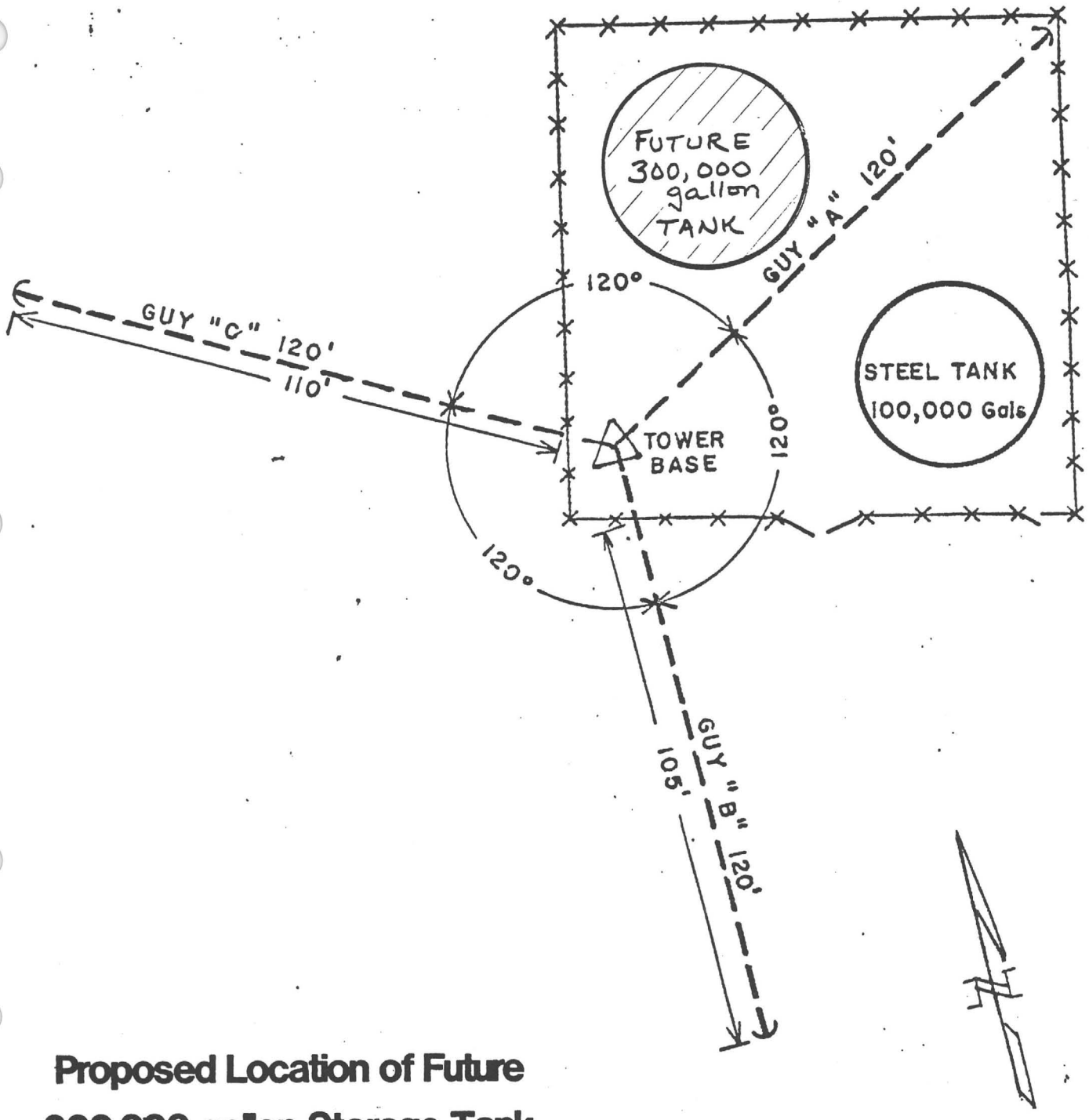
(602) 624-7401



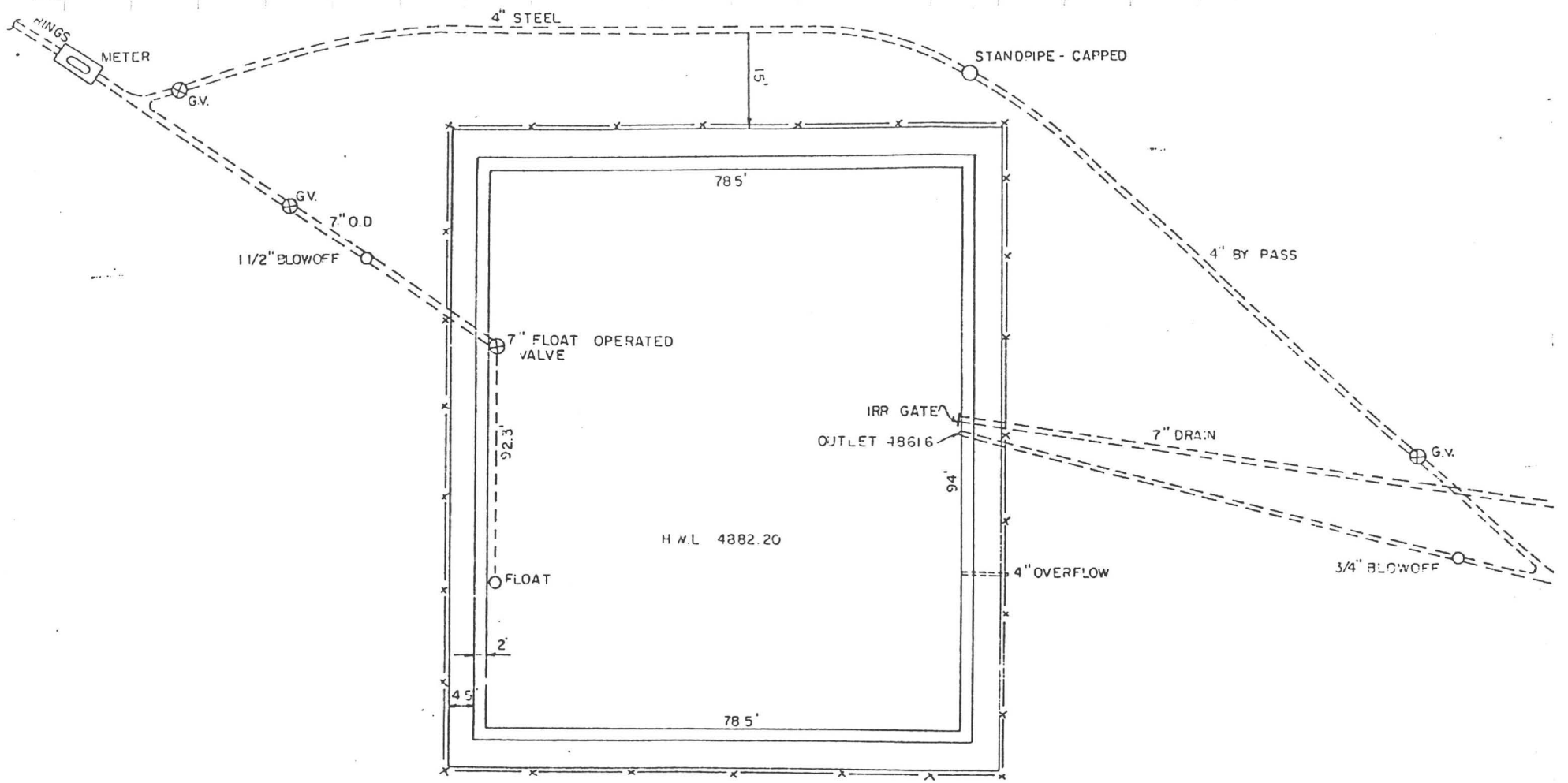
CITY TANK

FIGURE 3
SHEET 4 OF 6



Proposed Location of Future
300,000 gallon Storage Tank

FIGURE 3 SCALE: 1" = 30'
By: T.P.
12/27/77
SHEET 5 OF 6



1 M.G. CONCRETE RESERVOIR

FIGURE 3
SHEET 6 OF 6

APPENDIX A

Project Tombstone Water Date September 27, 1985

Job No. 60157-01-10 Compiled By DRV, EHB

SOURCE OF SUPPLY

Well #1

Location Allen St. E. of 6th St. Sec 11 T20S R22E

Date Drilled 1941 Discharge Elevation 4556 Source

Depth of Hole 612 feet Depth of Casing

Type of Casing Steel Diameter of Casing 4"

Perforations Unknown

Drilling Method NA Well Construction NA

Pump Setting 511 feet Static WL (1969) 430 feet

Pumping WL (1969) 490 feet Pumping Rate 225 gpm

Specific Yield 3.75 gpm/ft.

POWER AND PUMPING EQUIPMENT

Motor Type Franklin Electric, Subm. RPM H.P. 60

Voltage 480 Phase 3 Cycles 60 Amperes

Serial Number 00968 Model Number 2870015000

Frame Discharge Head Type --

Discharge Shaft -- Shaft Tubing -- Column --

Suction Pipe -- Air Tubing Lubrication --

Pump Manufacturer Pump Type Subm. Turbine

Size Stages TDH Capacity

Serial Number 314047 Impeller Curve Number

Project Tombstone Water Date September 27, 1985

Job No. 60157-01-10 Compiled By DRV, EHB

SOURCE OF SUPPLY

Well #2

Location Camino San Rafael Sec 1 T20S R22E

Date Drilled 1967 Discharge Elevation 4425 Source _____

Depth of Hole 600 feet Depth of Casing 352-486-600

Type of Casing Steel Diameter of Casing 12" - 10" - 6"

Perforations 3/8" x 6" 4 per foot - torch cut, 276' - 590'

Drilling Method NA Well Construction NA

Pump Setting 465 feet Static WL (1967) 276 feet

Pumping WL (1967) 338 feet Pumping Rate 300 gpm

Specific Yield 4.8 gpm/ft.

POWER AND PUMPING EQUIPMENT

Motor Type Gas - Waukesha RPM 1760 H.P. 90

Voltage -- Phase -- Cycles -- Amperes --

Serial Number 2BL90 Model Number _____

Frame _____ Discharge Head Type Amarillo, gear

Discharge _____ Shaft -- Shaft Tubing -- Column --

Suction Pipe _____ Air Tubing 445 feet Lubrication _____

Pump Manufacturer Layne & Bowler Pump Type Vertical Turbine

Size 8" Stages 23 TDH _____ Capacity _____

Serial Number 59000L Impeller _____ Curve Number _____

Project Tombstone Water Date September 27, 1985

Job No. 60157-01-10 Compiled By DRV, EHB

PUMPING EQUIPMENT

Booster Station Well 2 Booster

Location Camino San Rafael Sec 1, T20S, R22E

Pump No. 1 Type 3 Stage

Manufacturer Floway Model JOL Size 8

Capacity 450 GPM TDH 610 feet

Driver Waukesha Gas HP 40

Rotating Speed 3,500 RPM Voltage ----

Pump No. _____ Type _____

Manufacturer _____ Model _____

Capacity _____ TDH _____

Driver _____ HP _____

Rotating Speed _____ Voltage _____

Emergency Power _____

Remarks:

Project Tombstone Water Date September 27, 1985

Job No. 60157-01-10 Compiled By DRV, EHB

STORAGE RESERVOIRS AND TANKS

Name Well 2

Location Camino San Rafael Sec 1 T20S R22E

Type Ground Level Date Constructed _____

Construction Welded Steel

Capacity 25,000 gallons Dimensions 20 feet dia., 12-foot ht.

Base Elevation _____ Overall Height _____ Overflow Elevation _____

Height to Bottom _____ Operating Head Range _____

Inlet Piping _____ Outlet Piping _____ Riser Piping _____

Overflow Piping _____ Drain _____ Water Source _____

Level Control _____

Optional Equipment _____

Date Last Inspected _____ Cathodic Protection _____

Painting System: Interior _____ Exterior _____

Date Last Painted _____

Remarks:, piping:

Project Tombstone Water Date September 27, 1985

Job No. 60157-01-10 Compiled By DRV, EHB

SOURCE OF SUPPLY

Well #3

Location North Drive Sec 1 T20S R22E

Date Drilled 1976 Discharge Elevation 4520 Source _____

Depth of Hole 890 feet Depth of Casing 600'

Type of Casing P.E. Steel Diameter of Casing 12"

Perforations 3/16" x 3" 12 per foot, 340' - 590'

Drilling Method NA Well Construction NA

Pump Setting 550 feet Static WL (1976) 333 feet

Pumping WL (1976) 520 feet Pumping Rate 210 gpm (300)

Specific Yield 1.60 gpm/ft.

POWER AND PUMPING EQUIPMENT

Motor Type Franklin Sumbersible RPM 3515 H.P. 60

Voltage 460 Phase 3 Cycles 60 Amperes --

Serial Number 76-120-84 Model Number _____

Frame _____ Discharge Head Type _____

Discharge _____ Shaft -- Shaft Tubing -- Column --

Suction Pipe -- Air Tubing -- Lubrication --

Pump Manufacturer Floway Pump Type Subm. Turbine

Size 8" Stages 7 TDH 564 Capacity 300 gpm

Serial Number _____ Impeller _____ Curve Number BLKL

Project Tombstone Water Date September 27, 1985

Job No. 60157-01-10 Compiled By DRV, EHB

PUMPING EQUIPMENT

Booster Station Well 3 Booster

Location North Drive Sec 1, T20S, R22E

Pump No. 1 Type 8 Stage Centrifugal

Manufacturer Gilbert Model 77-736 (5-1/4" impeller)

Capacity 300 GPM TDH 580 feet

Driver Newman Electric HP 60

Rotating Speed 3,500 RPM Voltage 480

Pump No. _____ Type _____

Manufacturer _____ Model _____

Capacity _____ TDH _____

Driver _____ HP _____

Rotating Speed _____ Voltage _____

Emergency Power _____

Remarks:

Project Tombstone Water Date September 27, 1985

Job No. 60157-01-10 Compiled By DRV, EHB

STORAGE RESERVOIRS AND TANKS

Name Well 3

Location North Drive Sec 1 T20S R22E

Type Ground Level Date Constructed _____

Construction Welded Steel

Capacity 2 @ 25,000 gallons Dimensions 20 feet dia., 12-foot ht.

Base Elevation _____ Overall Height 12 feet Overflow Elevation _____

Height to Bottom _____ Operating Head Range _____

Inlet Piping _____ Outlet Piping _____ Riser Piping _____

Overflow Piping _____ Drain _____ Water Source _____

Level Control _____

Optional Equipment _____

Date Last Inspected _____ Cathodic Protection _____

Painting System: Interior _____ Exterior _____

Date Last Painted _____

Remarks:, piping:

Project Tombstone Water Date September 27, 1985

Job No. 60157-01-10 Compiled By DRV, EHB

STORAGE RESERVOIRS AND TANKS

Name City Tank

Location SE 1/4, Sec 11, T20S, R22E

Type Ground Level Date Constructed _____

Construction Welded Steel

Capacity 100,000 gallons Dimensions 25.95-ft. dia., 12-foot ht.

Base Elevation 4,674 Overall Height 29.7 ft Overflow Elevation _____

Height to Bottom _____ Operating Head Range _____

Inlet Piping 4" & 6" Outlet Piping 6" Riser Piping _____

Overflow Piping 4" dia. Drain 4" dia. Water Source _____

Level Control _____

Optional Equipment _____

Date Last Inspected _____ Cathodic Protection _____

Painting System: Interior _____ Exterior _____

Date Last Painted _____

Remarks:, piping:

Project Tombstone Water Date September 27, 1985

Job No. 60157-01-10 Compiled By DRV, EHB

STORAGE RESERVOIRS AND TANKS

Name Reservoir

Location NE 1/4, Sec 14, T20S, R22E

Type Ground Level Date Constructed _____

Construction Reinforced Concrete

Capacity 1.1 million gallons Dimensions 78′ x 93′ x 20′

Base Elevation 4,861 Overall Height 20′ Overflow Elevation 4,882

Height to Bottom _____ Operating Head Range _____

Inlet Piping 7" Outlet Piping 7" Riser Piping _____

Overflow Piping 4" Drain 7" Water Source artesian springs

Level Control _____

Optional Equipment _____

Date Last Inspected _____ Cathodic Protection _____

Painting System: Interior _____ Exterior _____

Date Last Painted _____

Remarks:, piping:

APPENDIX B

Fire Flow Requirements

Location	Available Fire Flow (gpm)	ISO Required Fire Flow (gpm)
Hwy 80 at Mobile Home Pk	600	1,000
Hwy 80 at Lookout Lodge	550	1,000
Fitch and 4th	550	1,000
Fremont and 4th	500	1,750
Allen and 6th	500	2,250
Fremont and 6th	500	2,500
North St. behind School	650	1,250
Ria Ho Rd and San Rafael	250	750
Fremont and 7th	500	2,250

APPENDIX C

RESULTS OF COMPUTER MODELLED DISTRIBUTION SYSTEM ANALYSIS

The following data represents the results of one "run" which simulated a fire flow of 2,500 gpm at Allen and 2nd Street (Node No. 54). Other domestic maximum day demands were also distributed throughout the remaining service area. The resulting flows in each pipe and pressures at each mode are shown on Sheets 5 thru 8. The residual pressure at the fire flow location is 49 psi, other system pressure ranged from 39 to 111 psi. A pipe flow velocity of 6 feet per second occurs in the 12 inch main (Pipe No. 82) from the tank and peak flow velocity of 12 feet per second occurs in the 8 inch pipe for one block approaching the hydrants.

Numerous additional model runs were made by CBA simulating various pipe size and fire flow combinations. These computer runs were used to locate and confirm areas needing new distribution pipe improvements.

A key map identifying the location of pipes and nodes referred to in the attached output has not been included with this report.

FIRE FLOW ANALYSIS FOR CITY OF TOMBSTONE WATER DISTRIBUTION SYSTEM
CRA JOB NO. 60157-01-10
JULY 1985

FLOWRATES ARE EXPRESSED IN GPM AND PRESSURE IN PSIG

PIPE NUMBER	LENGTH (FEET)	DIAMETER (INCHES)	ROUGHNESS	MINOR LOSS	PUMP CHARACTERISTICS			CONNECTING NODES	
1	640.00	6.0000	120.00	0.00	0.00	0.00	0.00	0	1
2	2600.00	3.0000	70.00	0.00	0.00	0.00	0.00	1	2
3	660.00	3.0000	70.00	0.00	0.00	0.00	0.00	2	3
4	500.00	6.0000	120.00	0.00	0.00	0.00	0.00	3	4
5	620.00	6.0000	120.00	0.00	0.00	0.00	0.00	4	5
6	320.00	6.0000	120.00	0.00	0.00	0.00	0.00	5	6
7	2150.00	6.0000	120.00	0.00	0.00	0.00	0.00	6	7
8	1950.00	6.0000	120.00	0.00	0.00	0.00	0.00	7	8
9	1420.00	6.0000	120.00	0.00	0.00	0.00	0.00	0	8
THERE IS A CHECK VALVE IN LINE NUMBER 9									
10	2450.00	6.0000	120.00	0.00	0.00	0.00	0.00	8	9
11	410.00	6.0000	120.00	0.00	0.00	0.00	0.00	9	10
12	960.00	8.0000	120.00	0.00	0.00	0.00	0.00	10	11
13	2070.00	6.0000	120.00	0.00	0.00	0.00	0.00	7	11
14	510.00	6.0000	120.00	0.00	0.00	0.00	0.00	7	12
15	1170.00	6.0000	120.00	0.00	0.00	0.00	0.00	12	13
16	360.00	6.3000	120.00	0.00	0.00	0.00	0.00	13	14
17	380.00	6.3000	120.00	0.00	0.00	0.00	0.00	14	15
18	1100.00	6.0000	120.00	0.00	0.00	0.00	0.00	15	16
19	370.00	6.0000	120.00	0.00	0.00	0.00	0.00	15	23
20	370.00	3.0000	70.00	0.00	0.00	0.00	0.00	14	24
21	400.00	3.0000	70.00	0.00	0.00	0.00	0.00	24	25
22	380.00	3.0000	70.00	0.00	0.00	0.00	0.00	25	26
23	320.00	6.0000	120.00	0.00	0.00	0.00	0.00	20	21
24	370.00	6.0000	120.00	0.00	0.00	0.00	0.00	21	22
25	400.00	6.0000	120.00	0.00	0.00	0.00	0.00	22	23
26	380.00	3.0000	70.00	0.00	0.00	0.00	0.00	23	24
27	390.00	3.0000	70.00	0.00	0.00	0.00	0.00	22	35
28	380.00	6.3000	130.00	0.00	0.00	0.00	0.00	21	26
29	360.00	6.3000	130.00	0.00	0.00	0.00	0.00	26	27
30	320.00	6.3000	120.00	0.00	0.00	0.00	0.00	27	28
31	440.00	6.3000	120.00	0.00	0.00	0.00	0.00	28	29
32	1100.00	3.3000	70.00	0.00	0.00	0.00	0.00	29	30
33	1070.00	6.0000	120.00	0.00	0.00	0.00	0.00	30	31
34	720.00	4.0000	100.00	0.00	0.00	0.00	0.00	31	32
35	810.00	3.0000	70.00	0.00	0.00	0.00	0.00	32	43
36	1350.00	6.0000	120.00	0.00	0.00	0.00	0.00	33	34
37	330.00	6.7000	130.00	0.00	0.00	0.00	0.00	33	35
38	380.00	6.3000	120.00	0.00	0.00	0.00	0.00	35	36
39	350.00	6.3000	120.00	0.00	0.00	0.00	0.00	36	37
40	360.00	6.3000	120.00	0.00	0.00	0.00	0.00	29	37
41	1100.00	6.0000	120.00	0.00	0.00	0.00	0.00	13	37
42	710.00	3.0000	70.00	0.00	0.00	0.00	0.00	20	39
43	430.00	6.0000	120.00	0.00	0.00	0.00	0.00	20	40
44	710.00	3.0000	70.00	0.00	0.00	0.00	0.00	39	40
45	360.00	6.0000	120.00	0.00	0.00	0.00	0.00	35	40
46	710.00	3.0000	70.00	0.00	0.00	0.00	0.00	37	38
47	360.00	6.0000	120.00	0.00	0.00	0.00	0.00	38	40
48	360.00	3.0000	70.00	0.00	0.00	0.00	0.00	40	41
49	330.00	3.0000	70.00	0.00	0.00	0.00	0.00	36	41

50	380.00	2.0000	65.00	0.00	0.00	0.00	0.00	41	42
51	370.00	4.0000	90.00	0.00	0.00	0.00	0.00	35	42
52	360.00	4.0000	100.00	0.00	0.00	0.00	0.00	42	43
53	360.00	2.0000	65.00	0.00	0.00	0.00	0.00	42	43
54	320.00	6.0000	120.00	0.00	0.00	0.00	0.00	33	43
55	380.00	6.0000	120.00	0.00	0.00	0.00	0.00	43	44
56	300.00	3.0000	70.00	0.00	0.00	0.00	0.00	44	45
57	370.00	6.0000	120.00	0.00	0.00	0.00	0.00	44	53
58	380.00	6.0000	120.00	0.00	0.00	0.00	0.00	40	53
59	430.00	6.0000	120.00	0.00	0.00	0.00	0.00	52	53
60	660.00	6.0000	120.00	0.00	0.00	0.00	0.00	47	52
61	380.00	6.1000	65.00	0.00	0.00	0.00	0.00	46	47
62	330.00	6.0000	120.00	0.00	0.00	0.00	0.00	44	46
63	50.00	2.0000	65.00	0.00	0.00	0.00	0.00	45	46
64	40.00	6.0000	120.00	0.00	0.00	0.00	0.00	47	48
65	250.00	6.0000	120.00	0.00	0.00	0.00	0.00	48	49
66	30.00	6.0000	120.00	0.00	0.00	0.00	0.00	49	50
67	230.00	2.0000	65.00	0.00	0.00	0.00	0.00	47	50
68	660.00	6.0000	120.00	0.00	0.00	0.00	0.00	50	51
69	270.00	6.0000	120.00	0.00	0.00	0.00	0.00	51	52
70	350.00	5.0000	80.00	0.00	0.00	0.00	0.00	52	54
71	350.00	5.0000	80.00	0.00	0.00	0.00	0.00	54	55
72	350.00	5.0000	80.00	0.00	0.00	0.00	0.00	55	56
73	450.00	5.0000	80.00	0.00	0.00	0.00	0.00	19	56
74	450.00	5.0000	80.00	0.00	0.00	0.00	0.00	19	20
75	500.00	5.0000	80.00	0.00	0.00	0.00	0.00	18	19
76	940.00	5.0000	80.00	0.00	0.00	0.00	0.00	17	18
77	450.00	7.0000	110.00	0.00	0.00	0.00	0.00	15	17
78	1820.00	6.0000	120.00	0.00	0.00	0.00	0.00	4	17
79	320.00	6.0000	120.00	0.00	0.00	0.00	0.00	5	16
80	530.00	4.0000	100.00	0.00	0.00	0.00	0.00	6	16
81	1900.00	7.0000	110.00	0.00	0.00	0.00	0.00	1	17
82	1970.00	12.0000	130.00	0.00	0.00	0.00	0.00	0	18
83	290.00	5.0000	80.00	0.00	0.00	0.00	0.00	19	57
84	350.00	12.0000	130.00	0.00	0.00	0.00	0.00	57	59
85	430.00	12.0000	130.00	0.00	0.00	0.00	0.00	59	60
86	130.00	6.0000	120.00	0.00	0.00	0.00	0.00	60	61
87	370.00	2.0000	65.00	0.00	0.00	0.00	0.00	61	63
88	300.00	6.0000	120.00	0.00	0.00	0.00	0.00	63	64
89	250.00	6.0000	120.00	0.00	0.00	0.00	0.00	62	63
90	350.00	12.0000	130.00	0.00	0.00	0.00	0.00	60	62
91	370.00	6.0000	120.00	0.00	0.00	0.00	0.00	61	62
92	340.00	6.0000	120.00	0.00	0.00	0.00	0.00	51	65
93	4250.00	6.0000	120.00	0.00	0.00	0.00	0.00	7	9
94	1870.00	6.0000	120.00	0.00	0.00	0.00	0.00	10	66
95	380.00	12.0000	130.00	0.00	0.00	0.00	0.00	18	66
96	380.00	12.0000	130.00	0.00	0.00	0.00	0.00	57	58
97	450.00	6.0000	130.00	0.00	0.00	0.00	0.00	19	21
98	300.00	8.0000	130.00	0.00	0.00	0.00	0.00	56	59
99	300.00	8.0000	130.00	0.00	0.00	0.00	0.00	55	60
100	300.00	8.0000	130.00	0.00	0.00	0.00	0.00	54	62

JUNCTION NUMBER	FLOWRATE	PIPE NUMBERS	ELEVATION	PATH FROM PREVIOUS JUNCTION
1	0.000	-1 2 81	4625.000	1
2	1.000	-2 3	4600.000	2
3	4.000	-3 4	4585.000	3

4	5.000	-4	5	78		
5	2.000	-5	6	79		
6	3.000	-6	7	80		
7	8.000	-7	8	13	14	93
8	0.000	-8	-9	10		
9	0.000	-10	11	-93		
10	-300.000	-11	12			
11	3.000	-12	-13			
12	0.000	-14	15	94		
13	7.000	-15	16	41		
14	2.000	-16	17	20		
15	4.000	-17	18	19	77	
16	5.000	-18	-79	-80		
17	4.000	76	-77	-78	-81	
18	1.000	75	-76	95	97	
19	5.000	73	74	-75	83	
20	4.000	23	42	43	-74	
21	4.000	-23	24	28	-97	
22	4.000	-24	25	27		
23	4.000	-19	-25	26		
24	2.000	-20	21	-26		
25	2.000	-21	22	-27		
26	4.000	-22	-28	29		
27	1.000	-29	30	-41		
28	1.000	-30	31	-42		
29	2.000	-31	32	40	44	
30	1.000	-32	33	-94		
31	13.000	-33	34			
32	12.000	-34	35			
33	6.000	-35	36	37	54	

4577.000	4
4577.000	5
4575.000	6
4495.000	7
4525.000	8
4425.000	10
4425.000	11
4450.000	12
4490.000	-13 14
4542.000	15
4548.000	16
4575.000	17
4572.000	18
4575.000	-18 77
4556.000	76
4545.000	75
4540.000	74
4548.000	23
4553.000	24
4560.000	25
4545.000	26
4540.000	21
4535.000	22
4520.000	29
4525.000	30
4502.000	31
4475.000	32
4450.000	33
4455.000	34

34	12.000	-36				
35	2.000	-37	38	51		
36	7.000	-38	39	49		
37	5.000	-39	-40	46		
38	5.000	45	-46	47		
39	6.000	-43	-44	-45		
40	4.000	-47	48	58		
41	4.000	-48	-49	50		
42	4.000	-50	-51	52	53	
43	3.000	-53	-54	55		
44	2.000	-55	56	57	62	
45	3.000	-56	63			
46	3.000	61	-62	-63		
47	5.000	60	-61	64	67	
48	5.000	-64	65			
49	4.000	-65	66			
50	4.000	-66	-67	68		
51	4.000	-68	69	91	92	
52	4.000	59	-60	-69	70	
53	3.000	-52	-57	-58	-59	
54	2504.000	-70	71	100		
55	2.000	-71	72	99		
56	2.000	-72	-73	98		
57	2.000	-83	84	96		
58	0.000	-82	-95	-96		
59	3.000	-84	85	-98		
60	3.000	-83	86	90	-99	
61	2.000	-86	87			
62	2.000	89	-90	-91	-100	

4505.000	35	
4450.000	36	
4502.000	-34	37
4502.000	38	
4505.000	39	
4528.000	46	
4532.000	45	
4522.000	-45	47
4515.000	48	
4510.000	50	
4502.000	53	
4505.000	55	
4490.000	56	
4490.000	63	
4497.000	61	
4497.000	64	
4500.000	65	
4500.000	66	
4517.000	68	
4517.000	69	
4512.000	59	
4526.000	-59	70
4530.000	71	
4535.000	72	
4547.000	-73	83
4540.000	96	
4540.000	-96	84
4533.000	85	
4533.000	86	
4526.000	-86	90

63	1.000	-87	88	-89	4526.000	89	
64	2.000	-88			4515.000	88	
65	2.000	-92			4515.000	-88	-89 -91 92

LOOP NUMBER PIPE NUMBERS

1	2	3	4	78	-81			
2	-6	79	-80					
3	77	-78	5	79	-18			
4	-7	80	-18	-17	-16	-15	-14	
5	41	30	31	32	-94	15		
6	19	26	-20	17				
7	-21	-26	-25	27				
8	-22	-27	-24	28				
9	-23	42	-30	-29	-28			
10	-31	-42	43	-44				
11	-40	44	-45	-46				
12	39	46	47	48	-49			
13	-48	58	-52	-50				
14	38	49	50	-51				
15	-32	40	-39	-38	-37	-35	-34	-33
16	47	51	53	-54				
17	52	-57	-55	-53				
18	-56	62	-63					
19	57	-59	-60	-61	-62			
20	-43	-74	73	-72	-71	-70	59	-58 -47 45
21	-19	77	76	97	24	25		
22	82	-96	-76	-81	-1			
23	69	70	100	-91				
24	60	-69	-68	-67				
25	-64	67	-66	-65				
26	86	87	-89	-90				
27	-11	-93	13	-12				
28	-8	93	-10					
29	16	20	21	22	29	-41		
30	-77	95	-96	-83				
31	23	-97	75	74				
32	-73	83	84	-98				
33	72	98	85	-99				
34	71	99	90	-100				

PATH NUMBER	ENERGY DIFFERENCE	PIPE NUMBERS								
1	169.000	1	2	3	4	5	6	7	8	-9

THESE ARE THE RESULTS FOR TRIAL NUMBER 5

PIPE NUMBER	FLOWRATE	HEAD LOSS	PUMP HEAD	MINORLOSS	VELOCITY	HL/1000
1	306.960	6.177	0.000	0.000	3.483	9.642
2	13.784	4.355	0.000	0.000	0.426	2.444
3	12.784	1.403	0.000	0.000	0.580	2.126
4	8.784	0.007	0.000	0.000	0.100	0.013
5	0.143	0.000	0.000	0.000	0.002	0.000
6	-63.594	-0.167	0.000	0.000	-0.722	-0.523
7	-89.059	-2.098	0.000	0.000	-1.011	-0.976
8	-76.501	-1.436	0.000	0.000	-0.868	-0.736

THE CHECK VALVE IN LINE NUMBER 9 IS CLOSED

10	-77.976	-1.869	0.000	0.000	-0.885	-0.763
11	-168.261	-1.300	0.000	0.000	-1.909	-3.170
12	131.739	0.476	0.000	0.000	0.841	0.496
13	-128.739	-3.996	0.000	0.000	-1.461	-1.931
14	198.466	2.195	0.000	0.000	2.252	4.304
15	111.140	1.721	0.000	0.000	1.261	1.471
16	-89.386	-0.229	0.000	0.000	-0.807	-0.636
17	-99.765	-0.357	0.000	0.000	-1.022	-0.941
18	-79.202	-0.864	0.000	0.000	-0.899	-0.785
19	180.765	1.339	0.000	0.000	2.051	3.620
20	16.879	1.316	0.000	0.000	0.766	3.557
21	17.947	1.594	0.000	0.000	0.815	3.985
22	17.395	1.429	0.000	0.000	0.789	3.761
23	-246.727	-2.061	0.000	0.000	-2.799	-6.440
24	-168.249	-1.173	0.000	0.000	-1.909	-3.169
25	-173.697	-1.345	0.000	0.000	-1.971	-3.362
26	3.068	0.057	0.000	0.000	0.139	0.151
27	1.448	0.014	0.000	0.000	0.066	0.038
28	26.776	0.027	0.000	0.000	0.276	0.072
29	40.171	0.055	0.000	0.000	0.413	0.152
30	223.697	1.355	0.000	0.000	2.302	4.236
31	214.353	1.722	0.000	0.000	2.206	3.914
32	-30.336	-7.296	0.000	0.000	-1.138	-6.623
33	55.989	0.442	0.000	0.000	0.635	0.413
34	43.989	1.921	0.000	0.000	1.123	2.668
35	31.989	9.415	0.000	0.000	1.452	11.623
36	12.000	0.032	0.000	0.000	0.136	0.024
37	-136.477	-0.415	0.000	0.000	-1.242	-1.257
38	-193.551	-1.231	0.000	0.000	-1.992	-3.240
39	-217.337	-1.207	0.000	0.000	-2.101	-3.448
40	232.699	1.640	0.000	0.000	3.395	4.557
41	184.526	4.137	0.000	0.000	2.094	3.761
42	-8.344	-0.685	0.000	0.000	-0.379	-0.965
43	204.328	1.953	0.000	0.000	2.318	4.542
44	9.990	0.956	0.000	0.000	0.453	1.347
45	-208.319	-1.695	0.000	0.000	-2.361	-4.708
46	10.462	1.023	0.000	0.000	0.470	1.441
47	213.681	1.776	0.000	0.000	2.425	4.935
48	-8.394	-0.351	0.000	0.000	-0.381	-0.976
49	16.786	1.232	0.000	0.000	0.762	3.521
50	4.692	0.923	0.000	0.000	0.448	2.439
51	55.075	0.921	0.000	0.000	1.063	2.490
52	52.760	1.345	0.000	0.000	1.347	3.736
53	2.706	0.357	0.000	0.000	0.276	0.991
54	151.466	0.835	0.000	0.000	1.719	2.609
55	151.172	0.988	0.000	0.000	1.715	2.600
56	19.033	0.407	0.000	0.000	0.455	1.357
57	4.324	0.001	0.000	0.000	0.049	0.004
58	218.075	1.947	0.000	0.000	2.474	5.124
59	-272.159	-3.476	0.000	0.000	-3.088	-7.724
60	67.299	0.383	0.000	0.000	0.764	0.581
61	138.848	2.424	0.000	0.000	1.524	6.378
62	134.815	0.694	0.000	0.000	1.530	2.103
63	7.033	0.290	0.000	0.000	0.718	5.809
64	44.490	0.021	0.000	0.000	0.732	0.537
65	59.490	0.116	0.000	0.000	0.675	0.462
66	55.490	0.012	0.000	0.000	0.630	0.406
67	2.059	0.149	0.000	0.000	0.210	0.597
68	33.349	0.251	0.000	0.000	0.408	0.380

69	-24.221	-0.024	0.000	0.000	-0.275	-0.088
70	309.237	17.634	0.000	0.000	3.053	50.382
71	-328.888	-19.765	0.000	0.000	-3.374	-54.472
72	-141.838	-4.163	0.000	0.000	-2.317	-11.895
73	113.054	3.517	0.000	0.000	1.847	7.815
74	-46.748	-0.695	0.000	0.000	-0.761	-1.523
75	103.173	3.299	0.000	0.000	1.686	6.598
76	87.989	4.618	0.000	0.000	1.438	4.913
77	-204.828	-1.139	0.000	0.000	-1.707	-2.530
78	3.641	0.005	0.000	0.000	0.041	0.003
79	61.737	0.257	0.000	0.000	0.700	0.495
80	22.465	0.407	0.000	0.000	0.574	0.769
81	293.176	9.340	0.000	0.000	2.444	4.916
82	2124.515	30.169	0.000	0.000	6.026	10.238
83	31.862	0.217	0.000	0.000	0.521	0.749
84	2028.939	3.290	0.000	0.000	5.755	9.401
85	1995.155	3.919	0.000	0.000	5.659	9.114
86	9.813	0.002	0.000	0.000	0.111	0.016
87	7.813	2.612	0.000	0.000	0.798	7.059
88	2.000	0.000	0.000	0.000	0.023	0.001
89	-4.813	-0.001	0.000	0.000	-0.055	-0.004
90	1793.292	2.618	0.000	0.000	5.087	7.480
91	69.770	0.230	0.000	0.000	0.792	0.621
92	2.000	0.000	0.000	0.000	0.023	0.001
93	-90.285	-3.252	0.000	0.000	-1.024	-1.001
94	87.625	1.759	0.000	0.000	0.991	0.941
95	-125.438	-0.021	0.000	0.000	-0.356	-0.054
96	-1999.077	-3.476	0.000	0.000	-5.671	-9.147
97	109.254	0.553	0.000	0.000	1.240	1.228
98	-30.784	-0.009	0.000	0.000	-0.196	-0.029
99	-189.050	-0.251	0.000	0.000	-1.207	-0.835
100	-1865.876	-17.393	0.000	0.000	-11.909	-57.992

JUNCTION NUMBER	ELEVATION	PRESSURE	GRADE LINE
1	4625.000	25.057	4682.823
2	4600.000	33.136	4676.468
3	4585.000	39.028	4675.065
4	4577.000	42.492	4675.058
5	4577.000	42.492	4675.058
6	4575.000	43.431	4675.225
7	4495.000	79.007	4677.323
8	4525.000	66.629	4678.759
9	4425.000	110.772	4680.628
10	4425.000	111.335	4681.977
11	4490.000	100.295	4681.451
12	4490.000	80.279	4675.260
13	4542.000	57.000	4673.539
14	4548.000	54.500	4673.768
15	4575.000	42.954	4674.126
16	4572.000	44.629	4674.989
17	4573.000	43.448	4675.264
18	4536.000	49.680	4670.646
19	4543.000	53.017	4667.347
20	4540.000	55.481	4668.032
21	4548.000	52.907	4670.093
22	4553.000	51.249	4671.266
23	4560.000	48.798	4672.611
24	4545.000	55.273	4672.553
25	4540.000	56.749	4670.959
26	4535.000	58.296	4669.530

27	4520.000	64.773	4669.475
28	4525.000	62.019	4668.120
29	4502.000	71.239	4666.398
30	4475.000	86.096	4673.683
31	4450.000	96.738	4673.242
32	4455.000	93.739	4671.320
33	4505.000	67.992	4661.906
34	4450.000	91.812	4661.873
35	4502.000	69.472	4662.320
36	4502.000	70.006	4663.551
37	4505.000	69.229	4664.758
38	4528.000	58.819	4663.735
39	4532.000	57.820	4665.430
40	4522.000	60.649	4661.959
41	4515.000	63.834	4662.310
42	4510.000	65.601	4661.387
43	4502.000	68.913	4661.030
44	4505.000	67.185	4660.043
45	4490.000	73.509	4659.635
46	4490.000	73.383	4659.345
47	4497.000	69.299	4656.921
48	4497.000	69.290	4656.900
49	4500.000	67.940	4656.784
50	4500.000	67.935	4656.772
51	4517.000	60.459	4656.521
52	4517.000	60.469	4656.545
53	4512.000	64.142	4660.020
54	4526.000	48.928	4638.911
55	4530.000	55.760	4658.676
56	4535.000	55.397	4662.839
57	4547.000	51.627	4666.139
58	4540.000	56.166	4669.615
59	4540.000	53.234	4662.849
60	4533.000	54.570	4658.930
61	4533.000	54.569	4658.928
62	4526.000	56.468	4656.312
63	4526.000	56.469	4656.313
64	4515.000	61.235	4656.313
65	4515.000	61.335	4656.541

THE AVERAGE (ABSOLUTE) CHANGE IN FLOWRATE FROM THE PREVIOUS TRIAL = 0.77950

APPENDIX D

CELLA BARR ASSOCIATES

Project Name: Tombstone Water System
Date Prepared: October 11, 1985
Engineer: EH Burgess
Project No. 60157-01-10
Owner/Developer: City of Tombstone
WP Code: F0391, EHB-17 (1)

PRELIMINARY COST ESTIMATE

ITEM NO.	ESTIMATED QUANTITY	UNIT	DESCRIPTION	UNIT PRICE	ESTIMATED COST
1.	3,860	LF	12" AC pipe*	$ 27.50	$ 106,150.00
2.	900	LF	8" AC pipe	$ 20.00	$ 18,000.00
3.	2,650	LF	6" AC pipe	$ 18.00	$ 47,700.00
4.	12	Ea.	Fire hydrants	$ 1,500.00	$ 18,000.00
5.	1	Ea.	300,000 gallon storage tank	$125,000.00	$ 125,000.00
6.	4	Ea.	Chlorination facilities	$ 5,000.00	$ 20,000.00
7.	1	Ea.	Booster pump (reservoir)	$ 15,000.00	$ 15,000.00
8.	1	Ea.	Booster pump (Well #3)	$ 30,000.00	$ 30,000.00
9.	1	Ea.	Automatic Controls (Well #2)	$ 9,000.00	$ 9,000.00
10.	2	Ea.	Repair valve vaults	$ 2,500.00	$ 5,000.00

*Cost of new pipe installation is partially dependent upon the trenching techniques which can be employed. If difficult trenching (requiring the use of explosives) is encountered, the cost will be much higher than if installation can be accomplished with standard trenching techniques. The cost shown above for this item has been adjusted to include difficult trenching for roughly one-third of the total length. If more or less difficult trenching is encountered, the cost will be higher or lower than this figure. Soil borings should be taken prior to bidding of this work to establish the level of trenching difficulty.

CELLA BARR ASSOCIATES

Project Name: Tombstone Water System
Date Prepared: October 11, 1985
Engineer: EH Burgess
Project No. 60157-01-10
Owner/Developer: City of Tombstone
WP Code: F0391, EHB-17 (2)

PRELIMINARY COST ESTIMATE

ITEM NO.	ESTIMATED QUANTITY	UNIT	DESCRIPTION	UNIT PRICE	ESTIMATED COST
11.	1	Ea.	Reservoir target	$ 2,500.00	$ 2,500.00
12.	1	LS	Reservoir roof repair	$ 500.00	$ 500.00
13.	1	Ea.	Backflow prevention valve	$ 1,500.00	$ 1,500.00
14.	1	LS	Refurbishment of valve vault between storage tank & reservoir	$ 25,000.00	$ 25,000.00
			Subtotal - Construction Costs		$ 423,350.00
			Engineering & Contingencies @ 15%		$ 63,500.00
			Total Costs for Improvements		$ 486,850.00

CITY OF TOMBSTONE
WATER SYSTEM
MAY 1985
1" = 200'
N
CBA CELLA BARR ASSOCIATES
MUNICIPAL SEWER PLANT
MOUNTAIN VIEW
MESA CIRCLE
CORTEZ DR.
SAN PEDRO WAY
SAN PEDRO
SAN RAFAEL
RIALTO RD.
RIALTO PL.
SADDLEBACK DR.
SADDLEBACK RD.
WELL NO. 2
RIDGE RD.
RIDGE PL.
U.S. 80
CALLE ENCANTO
AVENIDA HERMOSA
CALLE LAGUNA
AVENIDA DE LA LOMA
NORTH ST.
FITCH ST.
FULTON ST.
BRUCE ST.
SAFFORD ST.
FREMONT ST.
ALLEN ST.
TOUGHNUT ST.
FRONT ST.
AMM ST.
HASKELL ST.
SUMNER ST.
FIRST ST.
SECOND ST.
THIRD ST.
FOURTH ST.
FIFTH ST.
SIXTH ST.
SEVENTH ST.
EIGTH ST.
NINTH ST.
TENTH ST.
ELEVENTH ST.
TWELVTH ST.
THIRTEENTH ST.
FOURTEENTH ST.
CHARLES RD.
SEE DETAIL #1
SEE DETAIL #3
SEE DETAIL #4
PROPOSED 6"
PROPOSED 8"
PROPOSED 12"
PROPOSED 300,000 GALLON STORAGE TANK
CITY TANK
SAN RAFAEL
GILA DR.
GILA PL.
APACHE DR.
PAPAGO PL.
NAVAJO PL.
PIMA PL.
WELL NO. 3
NORTH DR.
ESCONDIDA
SAN PEDRO
SAN JOSE
CORONADO
SAN JOAQUIN
NORTH ST.
OLD BISBEE RD.
CONCRETE RESERVOIR