*CITY OF WRANGELL*
*Wrangell Island, Alaska*

# *PRELIMINARY ENGINEERING REPORT FOR WATER FILTRATION FACILITIES*


WILSON ENGINEERING
805 Dupont Street, Suite #7
Bellingham, Washington 98225
(360) 733-6100


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## *Summary*

The City of Wrangell's unfiltered water supply is not in compliance with USEPA's Surface Water Treatment Rule (SWTR). The SWTR requires filtration for all surface water supplies. Additionally, the City desires to improve the taste and appearance of the source water. The purpose of the Preliminary Engineering Report is to summarize the existing water quality, analyze the pilot plant results, and select a recommended treatment alternative. For the selected alternative, engineering calculations, site layout, and a cost estimate are presented.

The source is two surface reservoirs with approximately 66,700,000 gallons of storage. The water in the reservoirs meets Alaska Drinking Water Standards for all Primary Chemical Contaminants and for most Secondary Chemical Contaminants. Secondary Chemical Contaminants exceeding the maximum contaminant levels are color, iron, and manganese.

Two filtration processes were piloted as part of the preliminary engineering work: (1) slow sand filtration and (2) membrane filtration. Direct filtration package plants were also evaluated by visiting Craig, Alaska's plant. The results of the pilot plant work indicate that slow sand filtration with pre-ozonation and a roughing filter successfully treats the water to meet the SWTR, taste and appearance requirements. Membrane and direct filtration were not attractive alternatives because of high maintenance, operation costs, and backwash requirements. Slow sand filtration is recommended as the treatment alternative for these reasons. Yearly operating costs for the three alternatives are compared in Table 1.

***Table 1 - Yearly Operating Costs***

| Item | Slow Sand Filter | Membrane Filter | Direct Filtration |
|---|---|---|---|
| Labor | $45,000 | $100,000 | $135,000 |
| Power | $33,300 | $35,000 | $13,500 |
| Maintenance | $15,000 | $30,000 | $30,000 |
| Outside Testing | $5,000 | $5,000 | $5,000 |
| Sand Replacement | $12,000 | n/a | n/a |
| Chemical Costs | $7,000 | $12,000 | $47,000 |
| Equipment Replacement Fund | $10,000 | $25,000 | $25,000 |
| TOTAL | $127,300 | $207,000 | $255,500 |

A summary of the design criteria and component sizing for the slow sand filter is presented in Table 2.

| *Table 2 - Slow Sand Filter* | | |
|---|---|---|
| ***Design Criteria*** | | |
| Parameter | Peak | Average |
| Water Demand (gpm) | 900 | 600 |
| Ozone Dose (mg/l) | 10 | 8 |
| Ozone Contact Time (minutes) | 10 | 15 |
| Roughing Filter Rate (gpm/ft2) | 1 | 0.67 |
| Slow Sand Filter Rate (gpm/ft2) | 0.1 | 0.07 |
| Number of Slow Sand Filters | 4 | 4 |
| Sodium Hydroxide Dose (mg/l) | 3 | 3 |
| ***Component Sizing*** | | |
| Parameter | Peak | Average |
| Ozone Generation (lbs/day) | 108 | 57.6 |
| Ozone Contactor (gallons) | 9000 | 9000 |
| Roughing Filter Area (ft2) Total | 900 | 900 |
| Slow Sand Filter Area (ft2) Total | 9000 | 9000 |
| Slow Sand Filter Area (ft2) Each | 2250 | 2250 |

Construction will be completed in two phases. The first phase will consist of the Upper Reservoir waterline, service metering, powerline extension, and site work for the water plant and the water storage tank. The second phase will consist of the waterplant, 400,000 gallon water storage tank, and Zimovia Highway waterline. The costs of the phases are estimated as follows.

| *Table 3 - Estimated Costs* | |
|---|---|
| ***Phase I*** | $1,400,000 |
| ***Phase II*** | $4,000,000 |

## *Background*

The Surface Water Treatment Rule (SWTR) was developed by the USEPA to provide uniform design and operating criteria for surface water systems to achieve 99.9% reduction of Giardia cysts and 99.99% reduction of viruses in drinking water. The rule requires that all systems using surface water must have filtration as a treatment process and specified disinfection contact times prior to distribution or meet certain criteria for non-filtering systems. It would be difficult for the City to meet the non-filtering requirements, particularly control over the watershed as portions of the watershed are not owned by the City.

The City is currently not in compliance with the SWTR and will have to make improvements to the water system to meet the requirements. In addition to meeting the SWTR, the City desires to improve the appearance and taste of the water. For both of these reasons drinking water treatment is a high priority.

The purpose of this report is to complete the preliminary engineering work required to proceed with design and construction of water system improvements necessary to comply with SWTR. The scope of the report is to summarize the existing water quality, analyze the pilot plant results, and recommend a treatment alternative. For the selected alternative, engineering calculations, site layout, and a cost estimate are presented.

## *Source Water*

### *Quantity*

The source is two surface reservoirs providing storage as detailed below:

***Table 3 - Wrangell Reservoir Statistics***

| | Upper Reservoir | Lower Reservoir |
|---|---|---|
| Usable Storage (gals.) | 45,300,000 | 21,400,000 |
| Base Elevation | 339 (intake) | 273.5 (intake) |
| Overflow Elevation | 358' | 294 |

Combined, the reservoirs provide storage equal to approximately 60 days of current peak flows (1 mgd).

The reservoir's watershed is approximately 500 acres, most (~70%) of which directly feeds the upper reservoir. The lower reservoir is primarily fed with overflow from the upper reservoir. A third reservoir could be constructed in the stream bed between the upper and lower reservoirs. A third reservoir would not add much storage to the system, however, as the stream bed valley is narrow and the slope comparatively steep in the area available. The maximum usable storage a third reservoir could provide would be approximately 15,000,000 gallons.

## *Quality*

*Physical Parameters*

Typical physical parameters for the untreated water are summarized in Table 4.

| ***Table 4 - Physical Parameters for Reservoir Water*** | | | |
|---|---|---|---|
| Parameter | Low | Average | High |
| Temperature | 40°F | 50°F | 60°F |
| pH | 6.4 | 6.7 | 6.9 |
| Color | 40 | 55 | 60 |
| Turbidity | 0.7 NTU | 1.7 NTU | 4.0 NTU |

*Primary Chemical Contaminants*

Past testing for Inorganic, Organic, and Volatile Organic Chemical contaminants as listed in Alaska Drinking Water Standards 18 AAC 80 indicates that there are no contaminants tested for which exceed the Maximum Contaminant Level (MCL). The only contaminant which was detected was Total Trihalomethanes (TTHMs). TTHMs are common byproducts in water disinfected with chlorine as the chlorine reacts with organics in the water. TTHM sampling and analysis data are summarized in the following table and indicates that the values are well below the 0.100 mg/l MCL.

| ***Table 5 - Total Trihalomethane Analytical Data*** | |
|---|---|
| Sample Date | TTHM (mg/l) |
| May 1991 | <0.001 |
| October 1995 | 0.059 |
| November 1996 | 0.020 |

*Secondary Chemical Contaminants*

Secondary chemical contaminants mainly affect the aesthetic qualities of drinking water. At concentrations considerably higher than the MCL, health issues may become a factor. Wrangell water only exceeds the MCLs for color, iron, and, marginally, manganese.

| *Table 6 - Secondary Chemical Contaminants* | | | |
|---|---|---|---|
| Parameter | Units | Result | MCL |
| COLOR | Pt-Co units | 40 - 60 | 15 |
| CHLORIDE | mg/l | 1.0 | 250 |
| CONDUCTIVITY | $uS/cm^2$ | 23 | n/a |
| FLUORIDE | mg/l | <0.2 | 2.0 |
| HARDNESS | mg/l | 48 | n/a |
| SULFATE | mg/l | <1.0 | 250 |
| TDS | mg/l | 49 | 500 |
| IRON | mg/l | 0.5 - 1.5 | 0.3 |
| Mn | mg/l | 0.07 - 0.10 | 0.05 |
| SILVER | mg/l | <0.001 | 0.1 |
| TOC | mg/l | 4.0 - 7.0 | n/a |
| ZINC | mg/l | 0.014 | 5.0 |

## *Pilot Plant Study*

Two water filtration processes were piloted: (1) slow sand filtration and (2) membrane filtration. Direct filtration package plants were also evaluated by visiting Craig, Alaska's plant. Craig's plant is a direct filtration plant which treats a surface reservoir water similar to Wrangell's in color and turbidity.

## *Slow Sand Filtration*

### *Source water suitability*

Alaska's Water Treatment Guidance Manual lists raw water quality conditions necessary for particular treatment methods. These are compared in Table 7.

| *Table 7 - Alaska's Water Treatment Guidance Manual Slow Sand Filter Requirements* | | |
|---|---|---|
| Parameter | Guidance Manual Requirement | Wrangell's Raw Water |
| Total Coliforms (no./100 ml) | <800 | 1 - 300 |
| Turbidity (NTU) | <10 | 0.8 - 4 |
| Color (Pt-Co Units) | <5 | 40 - 60 |

This table indicates that, with the exception of color, Wrangell's raw water is suitable for slow sand filtration. Ozonation and carbon adsorption were tested as pretreatment methods to reduce the color to acceptable levels prior to slow sand filtration.

### *Pilot Plant Design*

*Slow Sand Filter*

The pilot plant was constructed from 2 foot diameter PVC piping with 1/2" PVC inlet and outlet piping. The PVC pipe was approximately 8 feet long to allow 1 foot of support media, 3 feet of sand media and 4 feet of freeboard above the sand. The flow into the filter was maintained at a constant rate (inlet control) to simplify operation and measurement of headloss.

Inlet flow was maintained at 0.10 gpm/ft$^2$. When the headloss built up to 36" the filter was scraped by lowering the water level to 5" below the sand and removing 1/4 to 1/2 inches of sand. The filter was then backfilled to 3-6 inches water over the sand and influent flow restarted.

*Sand and support media*

Several sands were tried during the pilot program. The sand and support media successfully used during the final phase of the project is characterized below.

| | $D_{10}$ | $D_{60}/D_{10}$ |
|---|---|---|
| Filter Sand No. 3 | 0.50 mm | 1.5 |
| Support media | 1.00 mm | 1.5 |

$D_{10}$ — Effective size (particle diameter which 10% by weight of sample are smaller)

$D_{60}/D_{10}$ — Coefficient of Uniformity (particle diameter which 60% by weight of sample are smaller divided by particle diameter which 10% by weight of sample are smaller)

Two sands ( Nos. 1 & 2) from Lone Star Northwest, Tacoma, Washington, were used unsuccessfully in initial pilot runs. The characteristics for these sands are summarized below. These sands had higher coefficients of uniformity than Sand No. 3. Ozonation and a roughing filter were not part of the initial pilot runs. It is likely that reducing the fines content of Filter Sands No. 1 & 2 and pretreating the water will allow these sands to be used successfully.

| | | $D_{10}$ | $D_{60}/D_{10}$ |
|---|---|---|---|
| Filter Sand | No. 1 | 0.29 mm | 2.41 |
| Filter Sand | No. 2 | 0.42 mm | 2.92 |

*Color removal*

Ozonation and activated carbon (Calgon F400, 12 x 40 mesh) where used as color removal methods. The activated carbon did not achieve necessary color removal in a cost effective manner. One pound of activated carbon per 4,000 gallons of water was necessary to achieve significant color removal. Color removal with activated carbon would cost approximately $70,000 annually plus shipping, handling, and disposal costs. Ozonation prior to filtration was an effective color removal process which also enhanced filter performance, increasing the length of filter runs from less than 20 days to greater than 30 days. For these reasons ozone was selected as the pretreatment color removal process.

*Pilot Ozone Generator*

The pilot ozone generator was a Hankin Ozotec Type 3 Model 3 capable of generating up to 1 pound per day of ozone with an air feed. The ozone generated had a concentration of 0.5% by weight and a flowrate of 20 scfh @ 12 psig. The ozone contactor was a four inch diameter column with a water depth of 17 feet with ozone diffused through a stone diffuser.

*Roughing Filter*

The roughing filter consisted of a 2 foot diameter PVC pipe approximately 8 feet high with 5 feet of 0.5 inch diameter pea gravel. The inlet discharged 4 feet from the bottom of the filter under 12 inches of pea gravel.

The purpose of the roughing filter was to remove a portion of the floc generated preozonation in order to reduce the load on the slow sand filter and increase run times.

*pH Adjustment*

Sodium Hydroxide was injected prior to the roughing filter to adjust the pH to approximately 7.3. Laboratory testing indicated that 12 ml of 0.01 N sodium hydroxide was required to adjust the pH per gallon of Wrangell's raw water. This is equivalent to 30 lbs of sodium hydroxide per million gallons of water treated or 3.6 mg/l. During pilot runs less than 3.0 mg/l were used to adjust the pH.

## *Results*

Several different configurations were tried starting during January 1996 with various filter sand and color removal methods. During September 1996 it was determined that the successful arrangement should be preozonation - pH adjustment - roughing filter - slow sand filter. Sand for the slow sand filter should have an effective size greater than 0.4 mm and be highly uniform (low coefficient of uniformity (~2.5)). A pilot plant with this configuration was placed in operation October 10, 1996 and was operated 82 days until January 1, 1997. By January 1, 1997 there was sufficient data to project the long term operating characteristics of the treatment process and allow full scale design.

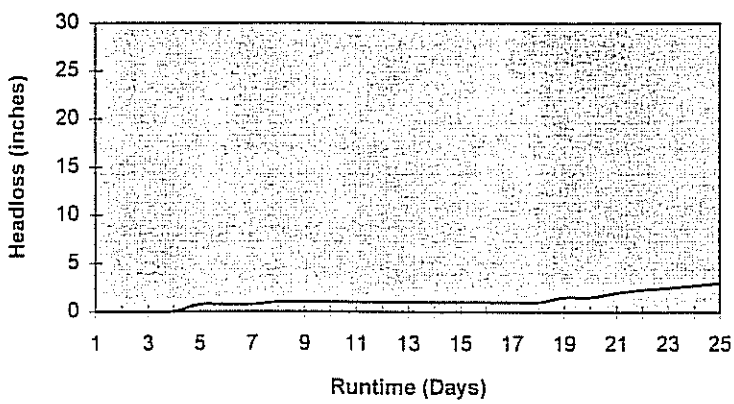
### *Application Rates*

Application rates developed in the pilot plant program are summarized below.

| | |
|---|---|
| Ozone Dose | 10 mg/l |
| Ozone Contact Time | 10 minutes |
| Sodium Hydroxide Dose | 3.0 mg/l |
| Roughing Filter | 1.0 gpm/ft$^2$ |
| Slow Sand Filter | 0.10 gpm/ft$^2$ |

### *Headloss/Scraping*

The following graph shows the buildup of headloss during the filter run.




October 5 - November 5, 1996 Slow Sand Filter Run

After 25 days the filter run was terminated because water system flushing had caused high turbidity in the raw water feed which caused rapid plugging of the slow sand pilot filter. After cleaning the media the filter was placed back on line December 5, 1996.

Ripening Intervals

Ripening intervals as measured by turbidity reduction where 1-2 days. Typically, during this period the effluent turbidity stabilized at 0.6 NTU or less.

*Slow Sand Filter Performance*

Table 7 presents the average raw and filtered values for turbidity, total coliform, and color.

| ***Table 7 - Slow Sand Filter Performance*** | | |
|---|---|---|
| Parameter | Raw Water | Filter Water |
| Turbidity (NTU) | 1.0 | 0.5 |
| Color (Pt-Co Units) | 55 | 7 |
| Total Coliform/100 ml | 50 | 1 |

*Total Trihalomethane (TTHM)*

TTHM samples, which is the sum of chloroform, trichloroethane, bromodichloromethane, and dibromochloromethane, were collected November 4, 1996 from Wrangell's water system at 105 2nd Street and at the Chlorine Shack. The results as shown in Table 8 indicate that the system is well within the MCL. After completion of the filtration plant the required chlorine dosage should be lower, lowering the potential to form TTHMs.

| ***Table 8 - Existing Water System TTHMs*** | | |
|---|---|---|
| Location | Result (mg/l) | MCL (mg/l) |
| 105 2nd Street | 20 | 100 |
| Chlorine Shack | 3 | 100 |

*Projected Run Times*

Typically, slow sand filters are operated until there is 40-60 inches of head over the sand surface. Pilot run times were restricted because of changes in the raw water feed and time constrains for the pilot program. Based on the available information run times between filter scrapings are projected to exceed 90 days. This exceeds the minimum run time of 30 days considered to be necessary for slow sand filtration to be operationally acceptable.

*Ability to meet water quality standards*

Table 9 compares typical pilot plant effluent data to the MCL. There is limited data for iron and manganese. The data indicates that, with the exception of iron, the effluent meets the required standard. The iron MCL is a secondary standard based on aesthetics and not related to a health issue.

**Table 9 - Slow Sand Filter Effluent Compared to MCLs**

| Parameter | Units | Filter Effluent | MCL |
|---|---|---|---|
| Color | Pt-Co units | 7 | 15 |
| Turbidity | NTU | 0.5 | 1 |
| Iron | mg/l | 0.4 | 0.3 |
| Manganese | mg/l | 0.027 | 0.05 |
| TOC | mg/l | 4.0 | n/a |

## Membrane Filtration

*Membrane Filter Pilot Plant*

The membrane filter pilot plant was a Memcor model 3M10C with automatic air stripping backwash. The membrane effective pore size is 0.2 micron. The membranes are arranged in bundles of hollow core fibers. The plant feed pressure was set at 28 psig. Backwashing intervals were set at 18 minutes. When the pressure loss across the membrane equaled 17 psig chemical cleaning of the membranes was required.

*Results*

The membrane filter was operated for approximately 4 weeks with the following results:

**Table 10 - Membrane Filter Effluent Compared to MCLs**

| Parameter | Units | Filter Effluent | MCL |
|---|---|---|---|
| Color | Pt-Co units | 45 | 15 |
| Turbidity | NTU | 0.1 | 1.0 |
| Run Time | Days | 3 | n/a |

*Evaluation*

The membrane filter performs well for turbidity removal but does not achieve adequate color removal as a stand alone process and has very high backwash and cleaning requirements. The cleaning process creates a sodium hydroxide and detergent waste stream that would have to be hauled or pumped to the sewer collection system. Piloting of the process was discontinued after 3 weeks because the backwash and cleaning requirements were unacceptable.

## *Direct Filtration*

Direct filtration is a water treatment process commonly using package plants. The process consists of chemical coagulation, flocculation, and multimedia filtration. Craig, Alaska uses this process to treat a water similar to Wrangell's. Operating results from Craig's plant were obtained and evaluated to determine the attractiveness of a direct filtration plant for Wrangell.

### *Craig, Alaska's Operating Data*

Raw Water Quality

***Table 11 - Comparison of Craig's & Wrangell's Raw Water Quality***

| Parameter | Units | Craig, Ak. | Wrangell, Ak. |
|---|---|---|---|
| Color | Pt-Co units | 40 | 55 |
| Turbidity | NTU | 0.7 | 1.7 |
| pH | units | 6.7 | 6.7 |

Flow Rate 5,500,000 gallons per month

Chemical Costs

| | |
|---|---|
| $Na_2CO_3$ | $425/month |
| Alum | $362/month |
| Polymer | <u>$98/month</u> |
| TOTAL | $885/month or $0.16/1000 gallons |

Backwash Requirements

Approximately 30% of the water filtered is used for backwash.

*Evaluation*

Craig's raw water quality is better than Wrangell's. It is likely that Wrangell's water would require higher doses of alum, polymer, and $Na_2CO_3$ because of the higher color content. The monthly chemical cost, excluding chlorination and pH adjustment, based on Wrangell's flowrate would be $3,400 ($41,000 annually) assuming that Wrangell's water did not require higher chemical doses than Craig's. The backwash rate for Craig indicates that 1.4 gallons of water are required to produce 1 gallon of usable water pumped into the distribution system with the other 0.4 gallons discharged as backwash, a waste stream. The alum sludge which settles out of the backwash is a solid waste which must be disposed of periodically.

High chemical costs, maintenance and operation requirements, and backwash rates are three negative factors for application of direction filtration to Wrangell's water treatment needs. The amount of water required for backwash is particularly unattractive to Wrangell as there is no surplus available for a backwash waste stream.

## *Preliminary Design*

Preliminary design is intended to develop and present all of the information necessary to proceed directly with the detailed engineering design and bid documents. Design calculations, component sizing, site layout, and a cost estimate are the basic elements of the Preliminary Design.

### *Project Description*

The purpose of the project is to complete preliminary engineering for a simple to operate water treatment plant capable of satisfying Wrangell's water demands through the year 2020. The City has two surface reservoirs which have historically provided adequate storage for the water system. A new water storage tank will be required when the treatment plant is constructed and the reservoirs will no longer directly feed the water system.

The reservoir water requires a water treatment system to reduce color, iron, manganese and meet the SWTR requirements. Table 12 summarizes current and future water demands. Future water demands are based on the projected population growth, approximately 1% per year as established by the City's 1995 Water System Assessment. Future water demands are assumed to increase proportionately to population growth. The demand projections assume that the City does not implement any water conservation measures such as water metering. The City's water usage per capita is high, approximately double the per connection national average. Installing water meters should reduce the water usage by at least 25%.

| *Table 12 - Wrangell's Water Demands* | | |
|---|---|---|
| 1994 Demands | Gallons per Day | Gallons per Minute |
| Average Day Demand | 705,000 | 489 |
| Maximum Day Demand | 1,057,000 | 734 |
| Max. Day, Peak Hour | - | 1285* |
| Projected Demands 2000 | | |
| Average Day Demand | 733,200 | 508 |
| Maximum Day Demand | 1,100,000 | 763 |
| Max. Day, Peak Hour | - | 1336* |
| Projected Demands 2020 | | |
| Average Day Demand | 871,000 | 604 |
| Maximum Day Demand | 1,306,000 | 906 |
| Max. Day, Peak Hour | - | 1586* |

### *Alternative Selection*

*Selected Alternative*

Slow sand filtration is the selected alternative because of the low operation and maintenance requirements compared to membrane and direct filtration.

*Alternatives Considered*

Three water treatment alternatives were evaluated as listed below:

1. Preozonation/Roughing Filter/Slow Sand Filter
2. Membrane Filter/Ozone
3. Package Direct Filtration Plant

The primary objectives of the City in selecting an alternative for design and construction include the ability to meet the regulatory requirements, produce aesthetically acceptable water for the system customers, and to be a cost effective solution to the City's current and future water demands.

*Regulatory Requirements*

All three alternatives will satisfy SWTR requirements. There are many proposed regulations which may or may not apply to smaller communities such as Wrangell. It is likely that the three alternative are equivalent in their ability to meet future more stringent limitations on additional contaminants.

*Ability to Meet Aesthetic Requirements*

All community water systems have two main aesthetic requirements, appearance and taste. Wrangell has an obvious appearance problem due to the brown color in the water from humic acids and turbidity, or lack of clarity, due to suspended solids. The three alternatives will be equivalent in meeting the aesthetic requirements.

*Cost Effectiveness*

The construction costs for the three alternatives are roughly equivalent at $3 million. The operating costs, however, will be significantly different.

*Labor and Maintenance*

Both membrane and direct filtration will require more operator attention. Additionally, direct filtration requires a significant amount of operator skill as the success of the process depends on selecting and maintaining a particular coagulant dose. Managing the chemical reactions in the coagulation process is crucial to the success and efficiency of direct filtration. Slow sand filtration and membrane filtration do not require chemical coagulation to work effectively. Membrane filtration does have a significant amount of equipment requiring maintenance, and the membranes need to be cleaned frequently in a labor intensive process.

*Power Costs*

Both slow sand filtration and membrane filtration have significant power requirements (840 kW-hr/day) because of ozonation. Direct filtration, because it uses chemical coagulation, has high chemical costs for alum, polymer, and soda ash. All alternatives will use NaOH (sodium hydroxide) to raise the pH of the water. Both membrane filtration and direct filtration have significantly more equipment than slow sand filtration and therefore require larger reserve funds for replacement of this equipment.

Annual operating costs of the three alternatives are compared in Table 13 which indicates that slow sand filtration has significantly lower operating costs.

**Table 13 - Yearly Operating Costs**

| Item | Slow Sand Filter | Membrane Filter | Direct Filtration |
|---|---|---|---|
| Labor | $45,000 | $100,000 | $135,000 |
| Power | $33,300 | $35,000 | $13,500 |
| Maintenance | $15,000 | $30,000 | $30,000 |
| Outside Testing | $5,000 | $5,000 | $5,000 |
| Sand Replacement | $12,000 | n/a | n/a |
| Chemical Costs | $7,000 | $12,000 | $47,000 |
| Equipment Replacement Fund | $10,000 | $25,000 | $25,000 |
| TOTAL | $127,300 | $207,000 | $255,500 |

*Site Requirements*

Membrane filtration has the lowest site requirement (5,000 $ft^2$) while direct and slow sand filtration have equivalent requirements (45,000 $ft^2$). Site requirements are not an important issue for this project as the City owns large land parcels available for locating the plant.

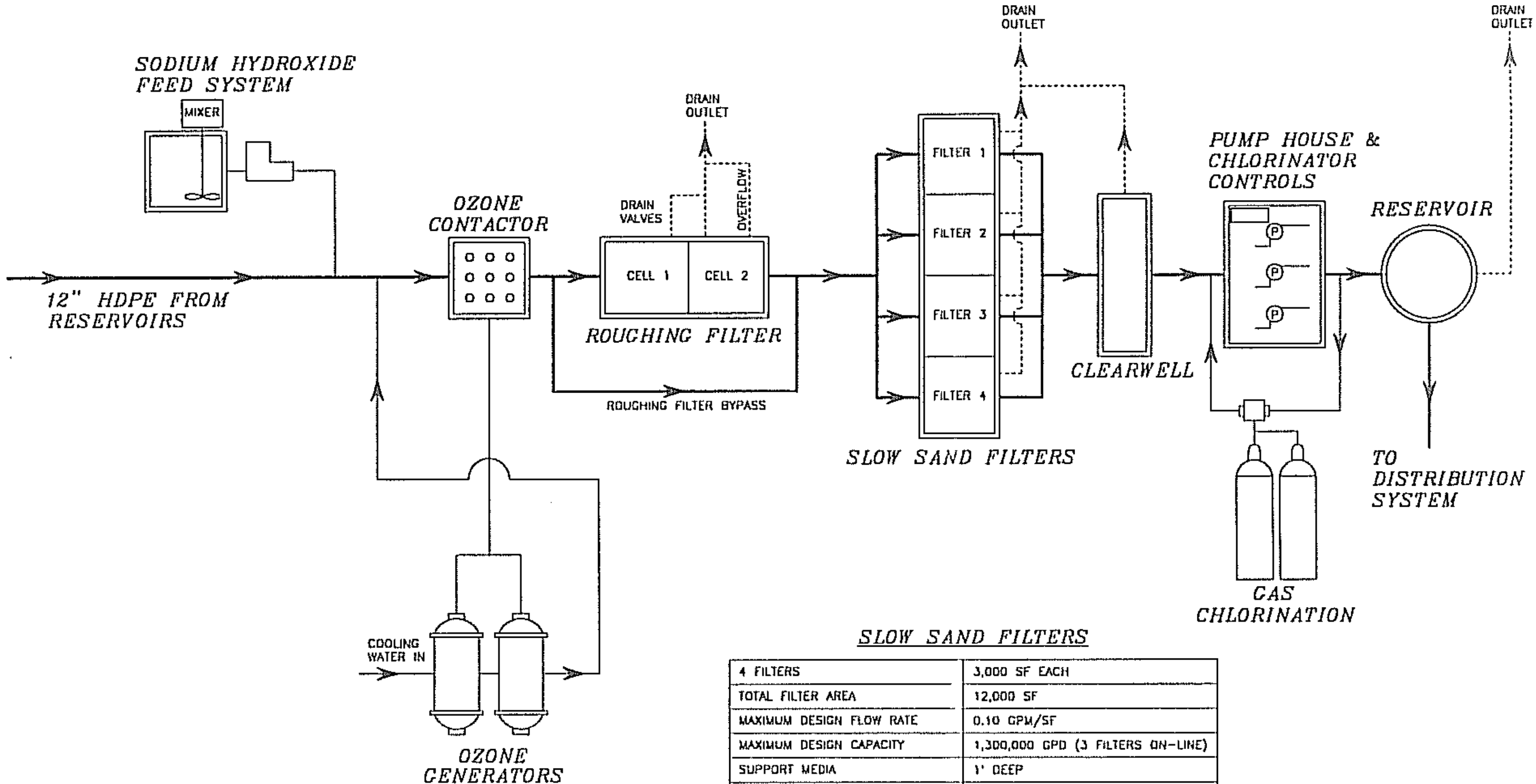
### *Design criteria & Component Sizing*

Figure 1 is a process schematic which illustrates the process, design criteria, and component sizing. A summary of the design criteria and component sizing calculations are presented below.

*Storage Reservoir*

The storage reservoir capacity (400,000 gallons) is based on the equalizing storage required plus fire flow as calculated below:

Equalizing Storage = (peak hourly demand - plant capacity) (150 minutes)
(1,586 gpm - 900 gpm) 150 minutes = 102,900 gallons
Fire Flow = 2,500 gpm x 120 minutes = <u>300,000 gallons</u>
Equalizing Storage + Fire Flow = 403,000 gallons




## UPFLOW ROUGHING FILTER

| | |
|---|---|
| 2 CELLS | 68'x13'x7' (LxWxD) |
| MEDIA | 4 TO 8 MM GRAVEL |

## RESERVOIR

| | |
|---|---|
| CAPACITY | 400,000 GALLONS |
| BASE ELEVATION | 310 FEET |
| MAX WATER SURFACE ELEV | 340 FEET |

## SLOW SAND FILTERS

| | |
|---|---|
| 4 FILTERS | 3,000 SF EACH |
| TOTAL FILTER AREA | 12,000 SF |
| MAXIMUM DESIGN FLOW RATE | 0.10 GPM/SF |
| MAXIMUM DESIGN CAPACITY | 1,300,000 GPD (3 FILTERS ON-LINE) |
| SUPPORT MEDIA | 1' DEEP |
| SAND BED | 4' DEEP |
| SUPERNATANT FREEBOARD | 5' |
| FINISH FLOOR ELEVATION | 245 FEET |
| MAXIMUM SUPERNATANT ELEVATION | 255 FEET |

Wilson Engineering
CONSULTING ENGINEERS & SURVEYORS
DUPONT STREET
BELLINGHAM, WA

DESIGNED BY: MAG
DRAWN BY: WAH
CHECKED BY:

**FIGURE 1 – PROCESS SCHEMATIC**

CITY OF WRANGELL – WATER TREATMENT PLANT
PRELIMINARY ENGINEERING REPORT

SCALE: N.T.S.
JOB NUMBER: 95112
SHEET 1 OF 1

C:\EP\95112\DWGS\FIGURE1 Thu Dec 26 11:27:13 1996 WAH

| Design Criteria | | |
|---|---|---|
| Parameter | Peak | Average |
| Water Demand (gpm) | 900 | 600 |
| Ozone Dose (mg/l) | 10 | 8 |
| Ozone Contact Time (minutes) | 10 | 15 |
| Roughing Filter Rate (gpm/ft2) | 1 | 0.67 |
| Number of Roughing Filters | 2 | 2 |
| Slow Sand Filter Rate (gpm/ft2) | 0.1 | 0.07 |
| Number of Slow Sand Filters | 4 | 4 |
| Sodium Hydroxide Dose (mg/l) | 3 | 3 |
| | | |
| **Component Sizing** | | |
| Parameter | Peak | Average |
| Ozone Generation (lbs/day) | 108 | 57.6 |
| Ozone Contactor (gallons) | 9000 | 9000 |
| Rough Filter Area (ft2) Total | 900 | 900 |
| Rough Filter Area (ft2) Each | 450 | 450 |
| Slow Sand Filter Area (ft2) Total | 9000 | 9000 |
| Slow Sand Filter Area (ft2) Each | 2250 | 2250 |
| Sodium Hydroxide Feed (lbs/day) | 32.4 | 21.6 |

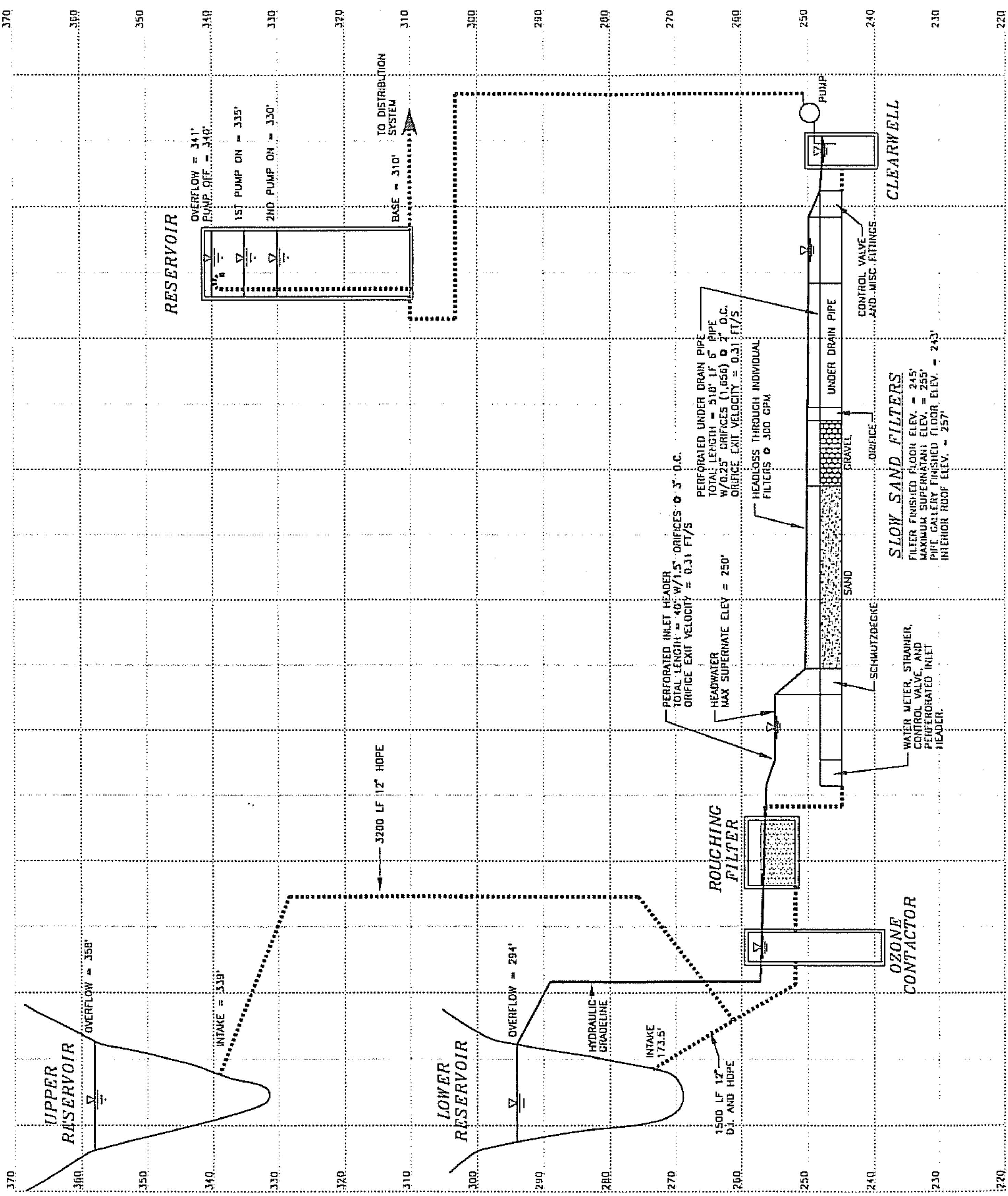
*Hydraulic analysis*

Figure 2 illustrates the hydraulic profile of the water plant and related reservoir system. The plant is located so that all of the usable storage in the lower reservoir can flow by gravity through the filtration process. The proposed 400,000 gallon water storage tank is located at an elevation that will boost the water pressure in the upper pressure zone approximately 20 psig during normal operating conditions.

*Estimated Power Requirements*

The exact power requirements will not be known until detailed engineering plans are near completion. The power demand factors can be estimated from the preliminary engineering information as summarized below:

| | KVA |
|---|---|
| Ozone Generating Equipment | 90 |
| Effluent Pumps (40 hp) | 40 |
| Lights, Receptacles, & Misc. | 30 |
| Heating | 40 |
| | 200 (equivalent to 268 hp) |
| Amperes @ 480V | 241 amps |




**Wilson Engineering**
CONSULTING ENGINEERS & SURVEYORS

805 DUPONT STREET
BELLINGHAM, WA 98225
(360) 733-6100
FAX: (360) 647-9061

| | | | |
|---|---|---|---|
| DESIGNED BY: MAC | FIGURE 2 – HYDRAULIC PROFILE | DATE 12/23/96 | SHEET 1 |
| DRAWN BY: WAH | BELLINGHAM / WASHINGTON — CITY OF WRANGELL – WATER TREATMENT PLAN | SCALE N.T.S. | OF |
| CHECKED BY: | PRELIMINARY ENGINEERING REPORT | JOB NUMBER 95112 | 1 |

C:\EP\95112\DWGS\FIGURE2 Thu Dec 26 11:33:50 1996 WAH

Site Layout

Figure 3 illustrates the plant layout and Figure 4 the general site layout with the reservoirs and main water supply lines.

*Land ownership and right-of-way issues*

The water plant will be constructed on Parcel 7 and the reservoir on Parcel 9 both of which are owned by the City. The General Site Layout (Figure 4) shows the parcels and location of facilities to be constructed.

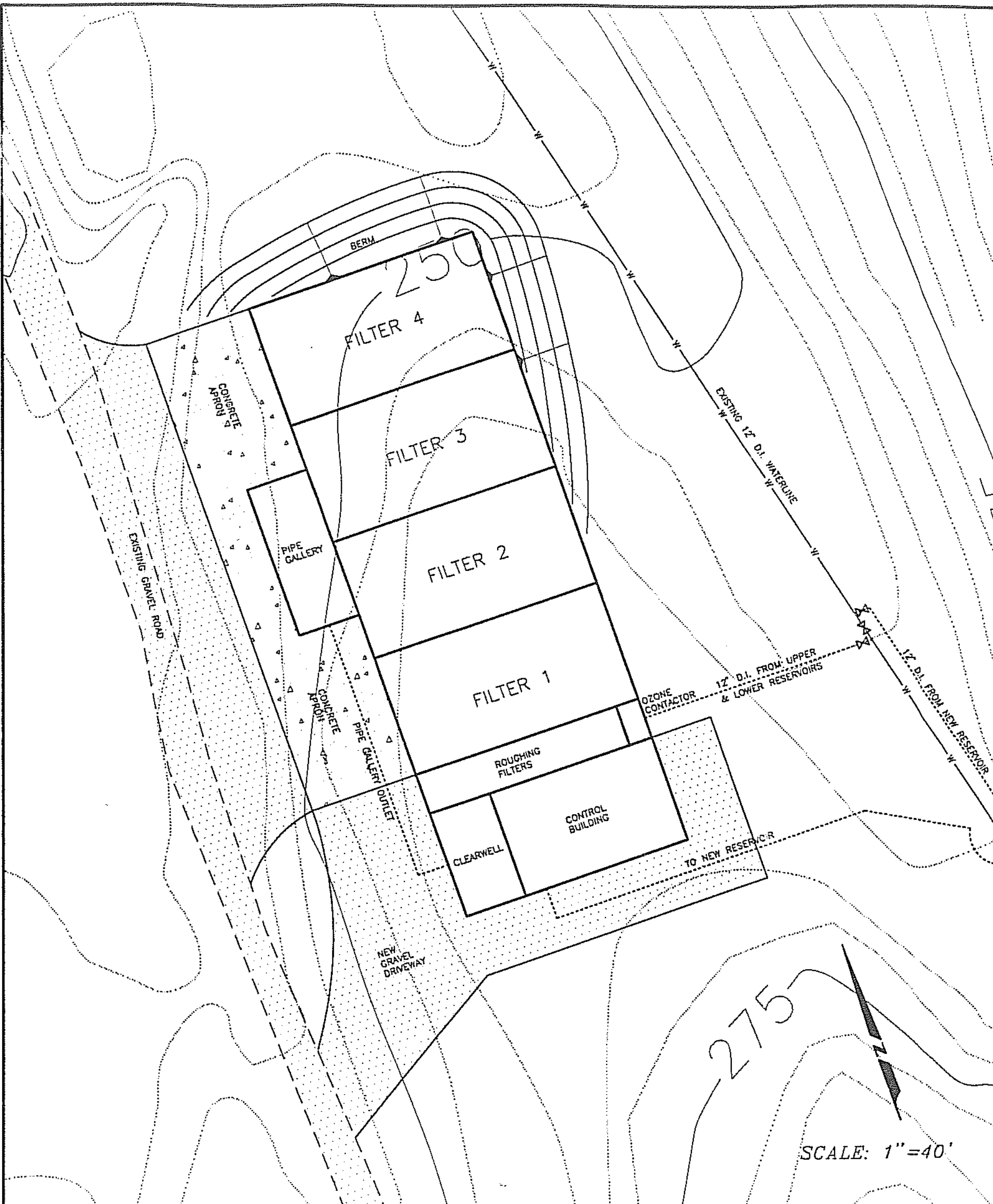
*Project Schedule and Phasing*

| ***Table 14 - Project Schedule and Phasing*** | | |
|---|---|---|
| | Design Phase | Construction Phase |
| Preliminary Engineering | 11/95 - 1/97 | n/a |
| ***Phase I***<br>Upper Reservoir 12" Waterline, Powerline Extension & Site Grading | 11/96 - 2/97 | 6/97 - 10/97 |
| ***Phase II***<br>Water Plant, Reservoir, & High Pressure 12" Waterline | 3/97 - 11/97 | 4/98 - 11/98 |

***Cost Estimate***

Table 16 presents an estimate of construction and engineering costs. The construction work is divided into five main items: (1) Upper Reservoir Waterline, (2) Slow Sand Filter Water Plant, (3) 400,000 Gallon Water Storage Tank, (4) Waterline to Zimovia Highway Waterline, and (5) Water Meters. The cost estimate indicates that the engineering and construction total for the five main items is $5,400,000. Table 15 presents the estimated division of total project costs between Phase I and II.

| ***Table 15 - Total Project Cost*** | |
|---|---|
| ***Phase I*** | $1,400,000 |
| ***Phase II*** | $4,000,000 |

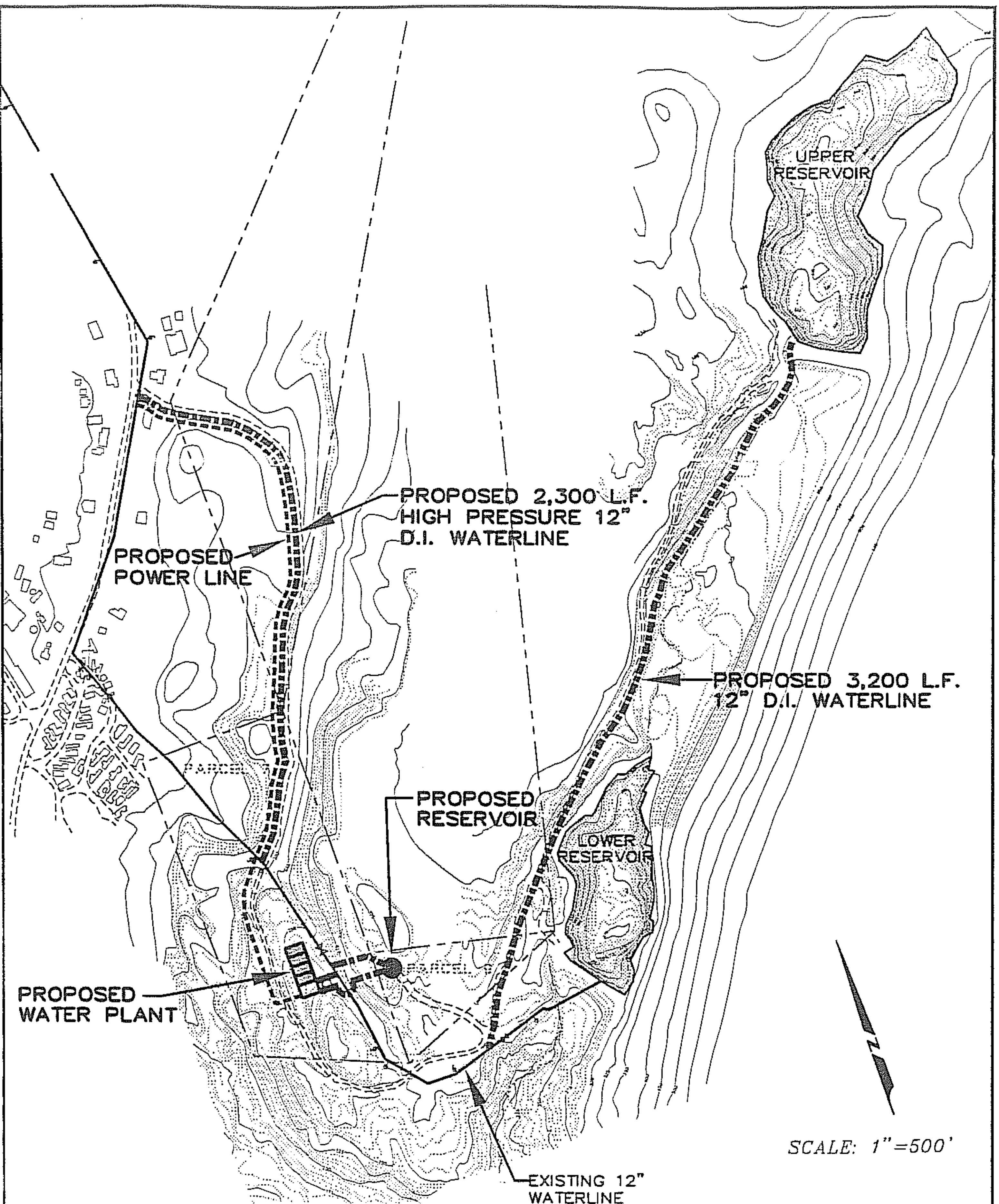



**Wilson Engineering**
CONSULTING ENGINEERS & SURVEYORS

DUPONT STREET
BELLINGHAM, WA

| DESIGNED BY: MAC | FIGURE 3 – WATER PLANT SITE PLAN | | SHEET |
|---|---|---|---|
| DRAWN BY: WAH | CITY OF WRANGELL – WATER TREATMENT PLANT | SCALE 1"=40' | 1 |
| CHECKED BY: | PRELIMINARY ENGINEERING REPORT | JOB NUMBER | 1 |

C:\EP\96107\DWGS\FIGURE3 Thu Dec 26 12:05:24 1996 WAH




| | | | | |
|---|---|---|---|---|
| Wilson Engineering CONSULTING ENGINEERS & SURVEYORS | 185 DUPONT STREET BELLINGHAM, WA 98225 (360) 733-6100 FAX (360) 647-9061 | DESIGNED BY: MAC<br>DRAWN BY: WAH<br>CHECKED BY: | FIGURE 4 – GENERAL SITE PLAN<br>WRANGELL ALASKA<br>CITY OF WRANGELL – WATER TREATMENT PLANT<br>PRELIMINARY ENGINEERING REPORT | DATE 12/20/96<br>SCALE 1"=500'<br>JOB NUMBER 95112 | SHEET 1 OF 1 |

C:\EP\96107\DWGS\FIGURE1 Mon Dec 23 11:39:31 1996 WAH

| Table 16 - Wrangell Water Treatment Plant Cost Estimate<br>Slow Sand Filter | | | | |
|---|---|---|---|---|
| ITEM | QUANTITY | UNIT | UNIT PRICE | AMOUNT |
| ***UPPER RESERVOIR WATERLINE*** | | | | |
| Mobilization | 1 | LS | $20,000 | $20,000 |
| Upper Reservoir Intake | 1 | LS | $10,000 | $10,000 |
| 24" HDPE through Upper Reservoir Dam | 170 | LF | $300/LF | $51,000 |
| 12" HDPE Upper Reservoir Waterline | 3200 | LF | $100/LF | $320,000 |
| | | | **SUBTOTAL** | $401,000 |
| ***SLOW SAND FILTER WATER PLANT*** | | | | |
| Mobilization | 1 | LS | $120,000 | $120,000 |
| Excavation/Filling | 5000 | CY | $20/CY | $100,000 |
| Ozone Equipment | 1 | LS | $400,000 | $400,000 |
| NaOH Tank & Feed Pump | 1 | LS | $10,000 | $10,000 |
| Gas Chlorination Facilities | 1 | LS | $10,000 | $10,000 |
| Concrete | 1000 | CY | $400/CY | $400,000 |
| Filter & Pipe Gallery Roofing System | 13000 | SF | $20/SF | $260,000 |
| Filter Sand and Underdrain Gravel | 3500 | TONS | $100/TON | $350,000 |
| Piping, Fittings, and Valves | 1 | LS | $150,000 | $150,000 |
| Metal Building for Ozonation, Pumping & | 2000 | SF | $100/SF | $200,000 |
| Booster Pumping | 1 | LS | $80,000 | $80,000 |
| Electrical | 1 | LS | $150,000 | $150,000 |
| Power Line Extension to Water Plant | 2800 | LF | $25/LF | $70,000 |
| Site Work | 1 | LS | $100,000 | $100,000 |
| | | | **SUBTOTAL** | $2,400,000 |
| ***400,000 GALLON WATER STORAGE TANK*** | | | | |
| Mobilization | 1 | LS | $20,000 | $20,000 |
| 12" HDPE Influent & Effluent Water Lines | 700 | LF | $100/LF | $70,000 |
| Excavation/Filling | 1000 | CY | $20/CY | $20,000 |
| 400,000 Gallon Water Storage Tank | 1 | LS | $300,000 | $300,000 |
| 12' Wide Access Road | 400 | LF | $30/LF | $12,000 |
| | | | **SUBTOTAL** | $422,000 |
| ***WATERLINE TO ZIMOVIA HWY WATERLINE*** | | | | |
| Mobilization | 1 | LS | $15,000 | $15,000 |
| 12" DI Waterline | 2300 | LF | $100/LF | $230,000 |
| | | | **SUBTOTAL** | $245,000 |
| ***WATER METERS*** | | | | |
| Radio Read Water Meters | 1000 | EACH | $500 | $500,000 |
| | | | | |
| | | | TOTAL | $3,968,000 |
| | | 15% Contingencies | | $595,200 |
| | | Construction Costs | | $4,563,200 |
| Permitting/Engineering/Surveying/Geotechnical | | | | $587,300 |
| Contract Management/Inspection/O&M Manuals | | | | $251,700 |
| Engineering and Construction Total | | | | $5,402,200 |
| | | | | |

# *Appendix A*

*Analytical Data from Water Quality Sampling*

# *Appendix B*

*Pilot Plant Data*

| DATE | TIME OF DAY | TURBIDITY | | HEADLOSS - DEPTH OF WATER ABOVE SAND, INCHES | FLOWRATE (gpm) | RAINFALL (inches) | FILTER APPLICATION RATE, GPM/SF | TEMP., °F | | pH* | | TOTAL COLIFORM* | | FECAL COLIFORM* | | COLOR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RAW WATER, NTU | FILTERED, NTU | | | | | RAW | AMBIENT | RAW | FILT. | RAW | FILT. | RAW | FILT. | RAW | FILT. | RAW |
| 21NOV96 | 9:30 | Ø.75 | Ø.43 | 5.5" | .30 | | .94° | 45.7 | 18 | 6.3 | 6.8 | 2 | 4 | Ø | 1 | 3 | 3 | 45 |
| 21NOV96 | 11:00 | SHUT DOWN TO INSPECT FOR OZONE LEAK ON OZONE UNIT. FOUND NO LEAK. BACK ON LINE AT 12:00 | | | | | | | | | | | | | | | | |
| 25NOV96 | 8:00 | SHUT DOWN FOR 4 HRS TO CHANGE COMPRESSOR AND REMOVE METERING | | | | | | | | | | | | | | | | |
| 25NOV96 | 1:30 | Ø.75 | Ø.50 | 8 15/16" | .30 | | .94 | 43.7 | 40 | 6.6 | 6.7 | Ø | 1 | Ø | Ø | 9 | 7 | 47 |
| 26NOV96 | 9:30 | Ø.72 | Ø.49 | 9.75" | .30 | | .94 | 47.5 | 40 | 6.6 | 6.8 | | | | | 9 | 7 | 49 |
| 27NOV96 | 9:30 | Ø.67 | Ø.48 | 12" | .30 | | .94 | 47.7 | 42 | 6.5 | 6.7 | | | | | 1 | 1 | 49 |
| 28NOV96 | 8:20 | Ø.71 | Ø.65 | 13.75" | .30 | | .94 | 47.8 | 40 | 6.3 | 6.6 | | | | | 3 | 5 | 47 |
| 29NOV96 | 8:30 | Ø.50 | Ø.38 | 15.50" | .30 | | .94 | 47.8 | 40 | 6.3 | 6.5 | | | | | 2 | 1 | 47 |
| 02DEC96 | 12:00 | Ø.67 | Ø.42 | 20" | .30 | | .94 | 46 | 38 | 6.6 | 6.7 | Ø | Ø | Ø | Ø | 2 | 1 | 46 |
| 03DEC96 | SHUT DOWN UNIT TO REPLUMB AND CLEAN SAND. WHILE CLEANING SAND, DISCOVERED "RED" IN THE TOP 2" OF THE SAND AND "BLACK" IN THE BOTTOM PORTION OF THE SAND. AT 9:00 A.M. ON 06DEC96 SLOW SAND FILTER PUT BACK ON LINE AT 11:00 A.M. 06DEC96 SODIUM HYDROXIDE WAS INTRODUCED INTO THE SYSTEM. | | | | | | | | | | | | | | | | | |
| 09DEC96 | 10:00 | Ø.75 | Ø.45 | 6" | .30 | | .94 | 45.9 | 35 | 7.1 | 7.1 | | | | | [illegible] | 2 | 44 |
| 10DEC96 | 12:30 | Ø.65 | Ø.52 | 6" | .30 | | .94 | 46.6 | 39 | 7.3 | 7.3 | | | | | | | |
| 11DEC96 | 10:00 | Ø.60 | Ø.49 | 6" | .30 | | .94 | 45.5 | 37 | 7.0 | 7.2 | | | | | | | |
| 12DEC96 | 10:30 | Ø.60 | Ø.50 | 6" | .30 | | .94 | 45.9 | 37 | 7.1 | 7.2 | | | | | | | |
| 17DEC96 | 10:30 | Ø.75 | Ø.46 | 6" | .30 | | .94 | 46.8 | 38 | 7.0 | 7.1 | | | | | 2 | 1 | 40 |
| 18DEC96 | 12:30 | Ø.56 | Ø.37 | 6" | .30 | | .94 | 46.8 | 46 | 7.0 | 7.0 | | | | | | | |
| 19DEC96 | 1:15 | Ø.57 | Ø.38 | 6.5" | .30 | | .94 | 45 | 42 | 7.0 | 7.1 | | | | | | | |
| 21DEC96 | 8:30 | Ø.50 | Ø.40 | 7.25" | .30 | | .94 | 43 | 18 | 6.6 | 6.7 | SODIUM HYDROXIDE FROZEN | | | | 1 | 5 | 45 |
| 22DEC96 | 8:25 | Ø.47 | Ø.30 | 8" | .30 | | .94 | 44.6 | 16 | 6.5 | 6.7 | | | | | | | |
| 23DEC96 | 10:00 | Ø.51 | Ø.39 | 9" | .30 | | .94 | 44.2 | 19 | 6.8 | 6.9 | | | | | | | |

* COMPLIANCE UNITS ONLY

OZONEDTA.XLW

DECEMBER 1996

| | | | | | | |
|---|---|---|---|---|---|---|
| | OZONE PRODUCTION | | | | | |
| | Date | Time | % Weight | Lbs./Day | Contact Time | Total GPM |
| 1 | | | | | | |
| 2 | DEC 96 | 12:00 | .55 | .30 | | |
| 3 | DEC 96 | 9:30 | .55 | .30 | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | DEC 96 | 8:00 | .55 | .30 | | |
| 8 | DEC 96 | 8:00 | .55 | .30 | | |
| 9 | DEC 96 | 10:00 | .55 | .30 | | |
| 10 | DEC 96 | 12:30 | .55 | .30 | | |
| 11 | DEC 96 | 10:00 | .55 | .30 | | |
| 12 | DEC 96 | 10:30 | .55 | .30 | | |
| 13 | | | | | | |
| 14 | | | | | | |
| 15 | | | | | | |
| 16 | | | | | | |
| 17 | DEC 96 | 10:30 | .55 | .30 | | |
| 18 | DEC 96 | 12:30 | .55 | .30 | | |
| 19 | DEC 96 | 1:15 | .55 | .30 | | |
| 20 | DEC 96 | 9:00 | .55 | .30 | | |
| 21 | ⊗ | | | | | |
| 22 | | | | | | |
| 23 | DEC 96 | 10:00 | .55 | .30 | | |
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Post-it® Fax Note 7671

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| Date 12-23 | # of pages ▶ 3 |
| To Marc Curtis | From Bob Caldwell |
| Co./Dept. Wilson Eng | Co. City of Whousell |
| Phone # | Phone # |
| Fax # | Fax # |

DECEMBER 1996

| UNTREATED WATER DATA | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | | | COLIFORM | | |
| DATE | NTU | pH | TOT | FEC | COLOR |
| [illegible] | 1.1 | 6.5 | 8 | 0 | 46 |
| [illegible] | 1.1 | 6.5 | | | 44 |
| 10DEC | 1.2 | 6.7 | | | |
| 11DEC | 1.0 | 6.6 | | | |
| 12DEC | 1.1 | 6.6 | | | |
| 13DEC | 1.0 | 6.6 | | | 46 |
| 18DEC | Ø.94 | 6.6 | | | |
| 19DEC | Ø.91 | 6.5 | | | |
| 21DEC | 1.71 | 6.3 | | | 45 |
| 22DEC | Ø.7Ø | 6.4 | | | |
| 23DEC | Ø.8Ø | 6.5 | | | |
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| ROUGHING FILTER SOLIDS REMOVAL | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MEASURED IN g/500mL | | | | | | | | PERCENT |
| | | | | | | | REMOVED | SOLIDS |
| DATE | TARE | | FILTERED | | SUS. SOL. | | SOLIDS | REMOVED |
| | IN | OUT | IN | OUT | IN | OUT | | |
| 12/8/96 | 2.8672 | 2.8540 | 2.872 | 2.8551 | 0.0049 | 0.0002 | 0.0047 | 96% |
| 12/9/96 | 2.8656 | 2.8499 | 2.873 | 2.8504 | 0.0077 | 0.0005 | 0.0072 | 94% |
| 12/10/96 | 2.8596 | 2.858 | 2.868 | 2.8596 | 0.0081 | 0.0006 | 0.0075 | 93% |
| 12/11/96 | 2.8516 | 2.8692 | 2.858 | 2.8697 | 0.0059 | 0.0005 | 0.0054 | 92% |
| 12/12/96 | 2.8698 | 2.8829 | 2.874 | 2.8831 | 0.0045 | 0.0002 | 0.0043 | 96% |
| 12/17/96 | 2.8795 | 2.8933 | 2.889 | 2.8936 | 0.0093 | 0.0003 | 0.009 | 97% |
| 12/23/96 | 2.8793 | 2.887 | 2.882 | 2.8892 | 0.0029 | 0.0022 | 0.0007 | 24% |
| 12/24/96 | 2.8897 | 2.8416 | 2.894 | 2.843 | 0.0038 | 0.0014 | 0.0024 | 63% |
| | | | | | | | | |
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