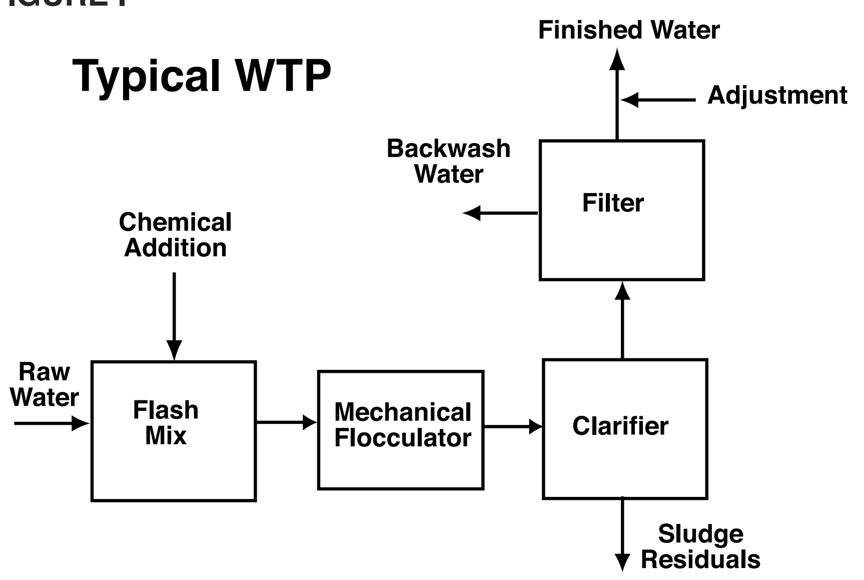
Jefferson Georgia, Water Treatment Plant (WTP) Filtration Experience

Jefferson, GA with a population of 2700 lies 15 miles north west of Athens or about north east of Atlanta.Superintendent Mile Arnold operates a conventional 2.0 MGD (design) surface WTP which is generically represented by **figure 1**.

FIGURE I



Like a number of surface water treatment plants in this part of the country Jefferson has a chronic raw water color problem. The color is largely caused by iron and manganese compounds in combination with organic contaminates. The town draws its water from a small 35 acre reservoir located on Curry Creek less than a mile away from the plant. Source water quality varies with the season and severe precipitation events cause a rapid increase in raw water turbidities. Table 1 is a list of the plants typical raw water parameters.

TABLE I

pH	7.1 - 7.5
Alkalinity (ppm)	20 - 24
Hardness (ppm)	24
Iron (ppm)	0.2 - 0.3
Manganese (ppm)	0.1 - 0.5

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Iron and manganese were removed by the addition of; Potassium Permanganate ($KMnO_4$) to oxidize the iron and manganese, and lime to increase the pH and reduce the solubility of metal oxides which were subsequently removed in the filtration process. Jefferson's treatment scheme is shown in **Figure 2**.

FIGURE 2

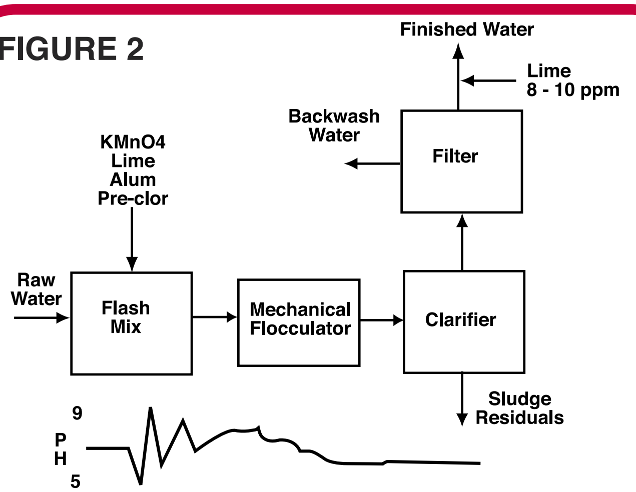
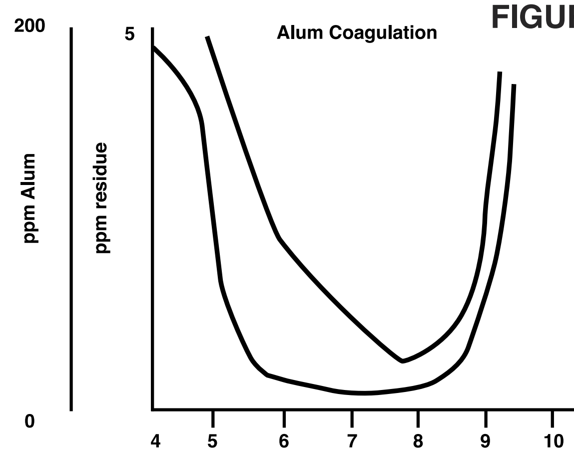


FIGURE 3



Although the plant was doing an adequate job of iron and manganese removal it was experiencing frequent periods of limited filter performance. Typical filter backwash cycles were twenty hours or less. The filter performance indicated that the flocculation and clarification processes were not working properly. The short filter life created unacceptable labor demands and derated the plant capacity.

Mike Arnold realized that he was not getting adequate performance from the alum he was adding. Knowing that pH is the single largest factor in the development of the aluminum hydroxide coagulant he undertook a study to determine the pH profile throughout the process. A graph of his findings showing pH from the flash mix tank to the clarifier appears at the bottom of **figure 2**.

The importance of pH control is graphically shown in **figure 3**,

The inside curve indicates Alum usage which is optimized in the pH range of 7.5 - 8.0 for most waters. This is the condition at which the alum is hydrolyzed to the active aluminum hydroxide species.

The outside curve represents aluminum residual after coagulation which has a minimum in the pH range of 6 - 8.

The pH curve at the bottom of **figure 2** illustrates the pH response from the flash mix tank to the settling tank as a result of the chemical additions. The profile is typical of flocculation processes in low alkalinity waters. Alum is an acidic salt and the conversion of one part of aluminum-sulfate to aluminum hydroxide consumes six parts of alkalinity. Thus waters that are low in alkalinity to start will readily become acidic. The addition of lime which is a strong alkali forces the pH into the basic (high pH) range because there is no alkalinity left to buffer the effects. The pH swings go beyond the optimum pH range (see **figure 3**) and result in poor floc formation which eventually results in turbid clarifier overflow and shorter filter cycles.

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Furthermore when the flocculation process is working properly, color forming colloids of metallic hydroxides (such as iron and manganese) are complexed with organic contaminates. These complexes become part of the organic flocs and are effectively removed from the water supply by filtration without oxidation.

By replacing lime in the Flash Mix chemical feed with sodium bicarbonate (which is 60 times more soluble than lime) it would provide the alkalinity required for hydroxilization of the alum, also it would buffer the pH in the optimum range for the reaction and subsequent flocculation.

After performing multiple jar tests to prove to themselves that this was true, Jefferson supervision decided to increase alkalinity at the front end of the treatment plant by supplementing raw water alkalinity with sodium bicarbonate. An additional 20 ppm of alkalinity measured as Calcium Carbonate was added to the Flash Mix to provide pH stabilization and replace lime and permanganate additions. The modified process is shown in **figure 4**.

FIGURE 4

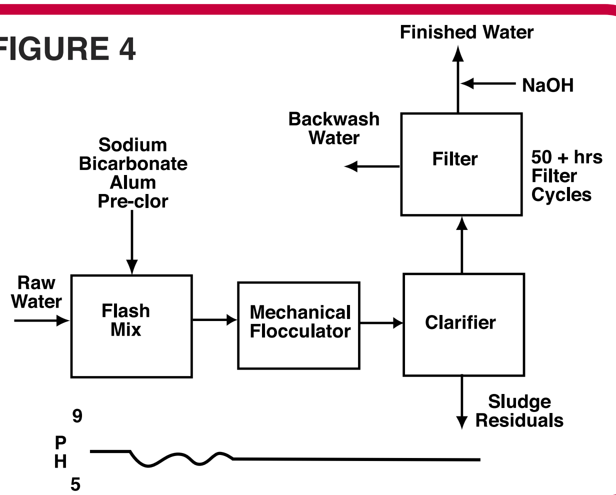

TABLE II

	Raw Water	Finished Water Before NaHCO3	Finished Water After NaHCO3
pH	7.1 - 7.5	7.5	7.5
Alkalinity (ppm)	20 - 24	10	35 - 40
Hardness (ppm)	24	28 - 30	24
Iron (ppm)	0.2 - 0.3	0.002	0.002
Manganese (ppm)	0.1 - 0.5	ND	ND
Filter Cycles (Hrs)		20	40 - 80

Figure 4 shows that the pH curve during the critical flocculation and coagulation processes were stabilized in the optimum range. This resulted in vastly improved filter cycle times and WTP operation.

A summary of Jefferson City's Raw and finished water parameters before and after the addition of sodium bicarbonate is shown in Table II. Iron and Manganese levels in the finished water remained at very acceptable levels. The alkalinity of the finished water has been raised significantly greatly improving corrosion control in the City's distribution and residential plumbing systems.

Jefferson made their switch to sodium bicarbonate over a year ago. The cost of the bicarbonate is offset by elimination of the lime and permanganate in the process. Additional savings were realized by elimination of expensive blended phosphates into the finished water for corrosion control.

Jefferson made the switch to Sodium Bicarbonate over one year ago and they remain satisfied with the results.

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