S&A-TSB-21

TECHNICAL ASSISTANCE PROJECT
VAIL WASTEWATER TREATMENT FACILITY
VAIL, COLORADO
MARCH - APRIL, 1973

town of vail

TECHNICAL SUPPORT BRANCH
SURVEILLANCE AND ANALYSIS DIVISION

U. S. ENVIRONMENTAL PROTECTION AGENCY
REGION VIII

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I. INTRODUCTION

On September 14, 1972 Region VIII of the Environmental Protection Agency (EPA), received a letter from the Colorado Department of Health requesting assistance concerning the operation of the Vail Wastewater Treatment Facility. An initial evaluation of the Vail plant was made on October 26 and 27, 1972. Various plant deficiencies were observed during the initial evaluation and recommendations were made to correct the observed problems. After the plant had been modified a formal technical assistance project was initiated on March 19, 1973.

The first objective of the assistance project was to improve effluent quality from the Vail facility by initiating a series of operational control tests and analyses. In addition, those portions of the facility which hindered or limited successful operation were to be identified. This report summarizes the results and findings of the technical assistance project and proposes several recommendations for future consideration at the Vail plant.

II. DESCRIPTION OF PLANT

A. BACKGROUND

Vail and the surrounding area is provided wastewater treatment by two separate Sanitation Districts. The Vail Sanitation District (VSD) serves primarily the Town of Vail and discharges its effluent into Gore Creek. The Upper Eagle Valley Sanitation District (UEVSD) serves localities upstream (The Big Horn Area) and downstream of the Town of Vail. The UEVSD discharges its effluent to the Eagle River downstream of the confluence of the River with Gore Creek.

Since a portion of the area served by the UEVSD is located upstream of the Vail facility, an agreement between the two districts was reached providing for a portion of Vail's collection lines to be used by the UEVSD to transport sewage to the Upper Eagle treatment plant.

Flow from the Big Horn area is measured prior to entering the Vail interceptors. This flow is transmitted to the Vail plant along with sewage from Vail. At the Vail facility the flow is split and an amount approximately equal to that flow measured from the Big Horn area is directed to the UEVSD plant. Vail is required to pay the UEVSD for all wastewater sent to the UEVSD plant in excess of that measured at the Big Horn metering station. It is noted that the interrelationship that exists between the plants provides a means to adjust flows to a desired quantity between the two facilities and therefore must be considered an important operational tool.

B. PLANT FACILITIES

Figure 1 shows the plant flow schematic for the Vail Wastewater Treatment facility. A brief discussion of each unit and its interrelationship with other units is described below.

Flow enters the plant and is directed through a parshall flume, bar screen, and grit channel before entering the aeration basins. Flow may enter the aeration basins at the head end, near aerator #3, half way down, near aerator #2, or at the far end of the basin, near aerator #1. A concrete wall is located near the end of the aeration basins and physically separates aeration basin #1 from basins #2 and #3. During the initial EPA evaluation made at the Vail plant it was recommended that an opening be provided in the wall between basin #1 and basins #2 and #3 to allow for series operation.

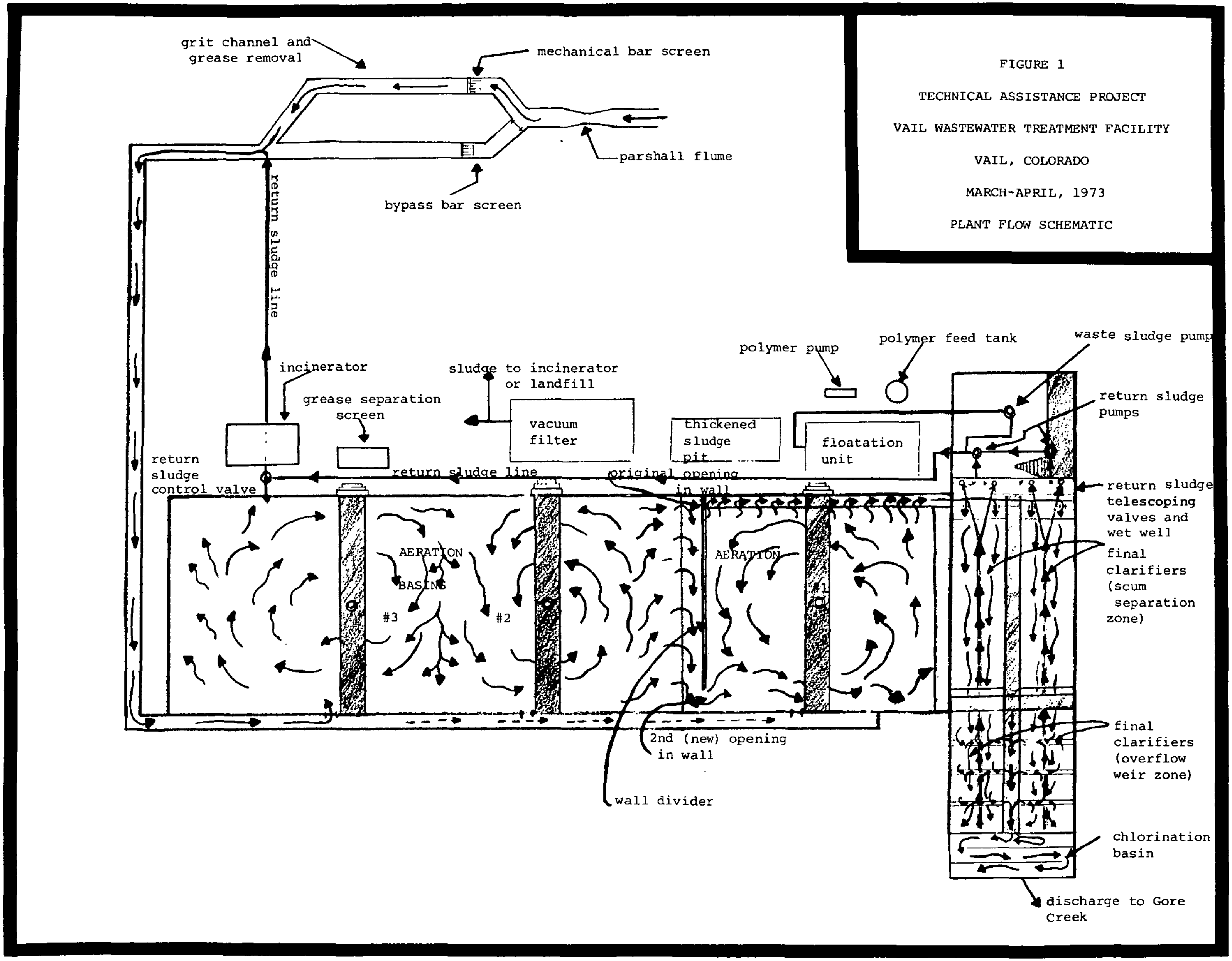

FIGURE 1

TECHNICAL ASSISTANCE PROJECT

VAIL WASTEWATER TREATMENT FACILITY

VAIL, COLORADO

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PLANT FLOW SCHEMATIC

Dissolved oxygen is introduced and mixing is provided in the aeration basins by three fixed surface mechanical aerators. After flow passes through the aeration basin it is directed to two rectangular final clarifiers. Flow to the clarifiers may be varied by manually adjusting the inlet gates. The clarifier effluent is chlorinated and discharged to Gore Creek.

Both final clarifiers are separated into two zones, a scum separation zone and overflow zone. Once each day, the scum is drawn off the front portion of the final clarifier, screened and incinerated. Settled sludge in the clarifiers is pulled by scrapers back to the head end of each clarifier. Sludge is removed from the clarifiers through four telescoping valves and is collected in a return sludge wet well. Return sludge flow rates are varied by adjusting the height of the telescoping valves. Sludge may be returned directly to aeration basin #3 or can be returned to the influent sewage channel.

Excess activated sludge is removed from the process (wasted) to a flotation type thickening unit. Polymer addition is used to affect the separation and flotation of the waste activated sludge. Thickened sludge is held in a storage tank and then dewatered on a vacuum filter. The filter cake can be either incinerated or buried. Supernatant from the sludge thickener and vacuum filter is recycled to the aeration basins.

III. SUMMARY OF LABORATORY ASSISTANCE

The major emphasis of the assistance project was to improve plant operational control and effluent quality. In addition, plant personnel were taught the procedures used in collecting, storing, and analyzing samples for the biochemical oxygen demand (BOD_5) and suspended solids tests.

Prior to the assistance project, plant personnel at Vail had infrequently collected grab samples of plant influent and effluent (prior to chlorination) and had performed a BOD_5 analysis on these samples using a proprietary method. Attempts were also made to conduct suspended solids analysis on these samples; however, adequate laboratory equipment was not available at the Vail plant. During assistance all plant personnel were taught the proper techniques used to collect, composite and store treatment plant influent and effluent (prior to chlorination) wastewater samples. Both influent and effluent samples were collected every two hours through the operational day (i.e. 8:00 am to 10:00 pm). No attempt was made to composite the samples proportional to flow. Samples were stored in a refrigerator until the following day.

Suspended solids and BOD_5 analyses were performed on the composited influent and effluent samples. Due to the nature of these analyses, the emphasis on plant operational controls, and the limited number of plant operators at the facility only two plant operators were given insturctions in the procedures used to run the BOD_5 and suspended solids analyses. Both operators were taught the proper techniques required to analyze wastewater samples for BOD_5 using the cylinder dilution technique as outlined in Standard Methods for the Examination of Water and Wastewater (1). Instruction was also given in determining the dissolved oxygen concentrations in the BOD_5 analysis using the azide-modification to the dissolved oxygen method again as listed in Standard Methods. The techniques used in conducting the suspended solids analysis using the gooch crucible and glan fiber filter method as listed in the manual entitled Operation of Wastewater Treatment Plants (2) was also explained to the operators.

As a result of the laboratory assistance all personnel at the Vail plant are capable of properly collecting, compositing and storing wastewater samples for the BOD_5 and total suspended solids analyses. Two operators are capable of properly performing the BOD_5 and total suspended solids analyses.

Conducting the laboratory tests; however, placed an additional responsibility on the Vail plant operators. In order to release the plant operators to do their other tasks and to provide for consistent laboratory data it is suggested that additional personnel be hired to perform primarily the laboratory functions. Consideration should also be given to sharing such a laboratory technican with the Upper Eagle Wastewater Treatment Facility.

IV. SUMMARY OF OPERATIONAL ASSISTANCE

A. CONTROL TESTING

In addition to instruction in conducting various laboratory tests, plant personnel were given instruction in conducting and interpreting various "control" tests. Centrifuge tests, turbidity, settleability tests, and sludge blanket depth were the control tests that were initiated. All except the settleability tests were conducted seven times per day seven days a week during the project. The settleability tests were conducted twice a day seven days a week.

Centrifuge tests were used to determine variations in solids concentrations from day to day. Tests were conducted on samples of mixed liquors taken at the discharge end of the aeration basin and on samples of return sludge. The centrifuge test values are expressed in percent solids by volume. Although it is not necessary for control, a correlation between percent solids by volume and solids by weight was made. The results of this correlation indicated that during the project one percent by volume was approximately equal to 690 mg/l by weight. This correlation will vary as the characteristics of the sludge vary. For this report all solids concentrations by weight were determined by using the correlation of one percent by volume equal to 690 mg/l by weight.

Turbidity tests were performed on samples of the effluent from the final clarifier. In all cases attempts were made to exclude any solids in the samples since test results were used to monitor the performance of the actived sludge process (i.e. the ability of the activated sludge to convert colloidal and dissolved BOD_5 to sludge solids).

Settleability tests were conducted on samples of the mixed liquor collected at the discharge end of the aeration basins. Settleability tests were used to monitor and observe sludge settling characteristics.

Sludge blanket depth determinations were made on the final clarifiers. Results were used to monitor changes in the depth of the blanket and to determine the amount of sludge that was accumulating in the final clarifier.

Data obtained from the various control tests were used to perform calculations and develop various graphs. The calculations and graphs were used to interpret plant performance and control plant operations. Since the termination of the Federal assistance project, Vail has purchased the equipment necessary to run the control tests and are using these tests to control plant operations.

B. PROCESS MODIFICATIONS

Many process modifications were made at the Vail Wastewater Treatment Facility as a result of the technical assistance effort. These modifications are outlined below:

A major deficiency which limited plant flexibility was noted during the October 26 and 27, 1972 on-site evaluation survey. The plant could not be operated in a "contact stabilization" mode nor could effective use of all the aeration basins be provided if the plant was operated in a "conventional" mode. The location of the opening in the concrete wall which separates aeration basin #1 from aeration basins #2 and #3 allowed flow from these basins to be directed only to the final clarifiers. In order for the plant to be operated in the "contact stabilization" mode the effluent from basins #2 and #3 should have been directed to basin #1, the contact zone. For the plant to be operated in the "conventional" mode all the sewage had to be entered into basin #3. However, if all the sewage were entered into aeration basin #3, basin #1 could not be used, thereby eliminating one third of the aeration capacity.

To eliminate the inadequacies posed by the concrete wall it was recommended that a second opening be placed in the concrete wall to enable flow from basins #2 and #3 to pass directly to basin #1. Plant personnel acted on this recommendation and a second opening in the wall was made prior to the beginning of the formal technical assistance project.

In order to discuss process modifications made during the formal technical assistance project it will be necessary to briefly outline operation of the plant prior to assistance. It is noted that approximately one week before assistance began significant process control changes were made. These changes are also outlined.

Using the new opening in the concrete wall, the Vail facility was operating in the "contact stabilization" mode. The major empahsis of plant operation was to control bulking and thereby eliminate the numerous citizen complaints that were received when bulking did occur. As a result of this operational emphasis little sludge bulking occurred; however, plant effluent quality was not completely satisfactory. The method used by plant operators to stop the bulking sludge was to decrease the return sludge flow rate (i.e. raise the four telescoping valves). Since the mode of plant operation at that time was contact stabilization the decreased return sludge flow rate served to decrease the quantity of sludge entering the re-aeration zone (basins #2 and #3) and thereby decrease the suspended solids being "displaced" to the contact zone. This decrease in "displacement" of solids resulted in a decrease in the mixed liquor suspended solids concentration (MLSS). The decreased MLSS concentration in the contact zone resulted in a lower solids loading to the final clarifiers and had the short term effect of stopping the sludge bulking. Plant effluent quality continued to be unsatisfactory; however, due to the larger quanities of colloidal and dissolved BOD_5 in the effluent caused by the inability of the lower concentrations of sludge in the contact zone to effectively convert BOD_5 to sludge solids. The practice of decreasing the return sludge flow rate at Vail in order to eliminate sludge bulking without considering other factors in plant operations such as sludge wasting, long term effects, aerator operation, etc., was unsatisfactory.

During the week before the assistance project a second factor, the volume of sludge wasted, was used as a means of controlling plant operation and specifically the sludge bulking problem. During this week the volume of sludge to be wasted was determined as a percentage of the volume of sewage flow received at the plant and was wasted irrespective of the waste sludge solids concentration. Using this approach, large quantities of sludge were wasted during this week, March 12-17, 1973. As the wasting was substantially increased, the return sludge flow rate was for the most part set at a low flow rate and maintained. This combination of large quantities of sludge wasted and low return sludge flow rates greatly reduced the MLSS concentration in the contact zone of the contact stabilization process. At the beginning of the assistance project the MLSS concentration in the contact zone had decreased to about 1000 mg/l. This low MLSS concentration in the contact basin greatly reduced the solids loading to the clarifier and no problems with sludge bulking occurred; however, plant effluent quality was unsatisfactory. Colloidal and dissolved BOD_5 remained in the effluent because the low concentration of sludge in the contact zone was inadequate to convert this BOD to removable sludge solids. The practice of controlling the quantity of sludge wasted and not adjusting the rate of return sludge flow also proved to be an unsatisfactory mode of operation.

At the beginning of the assistance project plant effluent quality was unsatisfactory. No problems with sludge bulking occurred, but large quantities of colloidal and dissolved BOD_5 were present in the plant effluent (effluent turbidity was about 20 JTU). The major emphasis at this point of the assistance project was to increase the MLSS concentration in contact with the sewage. Operational flexibility at Vail enabled the plant to be operated in either of three different modes of operation; contact stabilization, step loading, or conventional. Prior to formal assistance and after the opening between aeration basins #2 and #3 and basin #1 has been provided, the plant has been operated in the contact stabilization mode. The advantages of this mode of operation are claimed to be decreased plant upsets due to wide variations in hydraulic load and decreased operational controls required because of the relative insensitivity to changing hydarulic loads.

At the beginning of the assistance project the plant mode of operation was changed from contact stabilization to conventional. The change was made primarily to take immediate advantage of the sludge solids that were "stored" in the re-aeration zone (basins #2 and #3). For example the suspended solids concentration in the contact zone was about 1000 mg/l and the suspended solids concentration in the re-aeration zone was about 5000 mg/l. By distributing these solids throughout the system a desirable MLSS concentration of about 2700 mg/l throughout all the basins was achieved. In addition to the MLSS increase, the sewage detention time in the aerators also increased from about 7.3 hours to 21.9 hours (average flow of 1,703 cu m/day(450,000 gal/day).

Immediately after the change in the mode of operation sludge bulking occurred for approximately four days. Reasons for the bulking were high solids loading to the clarifiers and a relatively young and undeveloped sludge that exhibited poor settling characteristics. During this bulking period, every attempt was made to minimize solids lost and allow time for the settling characteristics of the sludge to improve. Close control over the return sludge flow rate was provided and the volume of sewage received at the plant was reduced by diverting flow to the Upper Eagle facility. After four days of maintaining the relatively high MLSS concentration coupled with a longer sewage detention time in the aerator, the settling characteristics as well as the removal characteristics of the sludge began to improve; (i.e. turbidity decrease from 20 JTU to 5 JTU).

The volume of sewage received at Vail prior to the assistance project was approximately 2,650 cu m/day(700,000 gal/day). During the four day period when problems with sludge bulking occurred the volume of flow received at Vail was reduced to about 1,628 cu m/day(430,000 gal/day). When the sludge began to settle better the flow rate to Vail was increased by 379 cu m/day(100,000 gal/day).

Additional flow was not accepted at Vail because of problems encountered with the operation of the final clarifier and continued sludge bulking. It should be pointed out that the ability to decrease the sewage flow to the Vail facility during the troublesome period greatly reduced the total pollutional load to the receiving stream and was a significant factor in maintaining a required high MLSS concentration. This interrelationship between the Vail plant and the Upper Eagle plant must continue to be used as an operational tool in future difficulties with either plant.

Numerous problems were encountered with the final clarifiers and attempts to improve their performance were attempted. The effect of poor clarifier performance was to allow solids to be lost in the plant effluent and although effluent quality was significantly improved it never reached an optimum because of the clarifier performance.

The major problem with the final clarifiers at Vail was inadequate control over flow splitting to the two clarifiers. Flow to the clarifiers was adjusted by opening or closing rectangular inlet gates. These adjustments; however, were not precise enough to attain equal flows to each clarifier. Also, rags and other debris would routinely clog the gate openings. High flow would be directed to one clarifier causing sludge bulking in that clarifier while the other clarifier would maintain a deep sludge blanket. Many different methods of splitting the flow equally to each clarifier to include using a butterfly splitter, 2 x 6 boards, etc., were tried to eliminate the splitting problem. However, all the methods tried required that the plant operators adjust and control the flow to each clarifier and balance the sludge blanket depth. Problems occurred during the night when plant operators were not on duty. Unequal flow to the clarifier continued unchecked and solids bulked over one or the other clarifier.

Major modifications to the Vail plant must be made in order to control adequately flow splitting to the two clarifiers. These modifications should provide for positive direct control over the flow to each clarifier. An intermediate solution would be to provide 24-hour operation so that the plant operators can make the necessary adjustments to prevent solids losses during the night.

The other major problems with the final clarifiers at Vail resulted from inadequate design features. The clarifiers are rectangular in shape and are separated into two zones. The first zone is a scum flotation zone where grease and other floating material is removed. The second zone is a weir overflow zone where the effluent weirs are located. Flow in the final clarifiers is directed through the scum removal zone to the overflow weir zone and discharges to the chlorine contact basin. The settled sludge in the clarifier is pulled countercurrent to the flow back to the head end of the clarifier and returned to the aeration basins. These countercurrent flow patterns have a tendency to create shear stresses in the sludge blanket and cause lower return sludge concentrations than would normally be expected, especially because of the shallow depth of the clarifier (approximately 9 feet). A through investigation of the proposed shear stresses in the final clarifier was not made, however, the effects of the stresses were observed in the results of the control tests. A method to correct the inadequate design features of the final clarifiers would be to complete major modifications (i.e. deeper clarifiers, co-current sludge removal, etc.). A second and more immediate method would be to reduce the flow to the clarifiers. Reduced flow would reduce the effects of the shallow depth and countercurrent flows. It is recommended that the second approach to reduce the flow to the final clarifiers, be considered. The maximum volume of flow these clarifiers are capable of accepting should be determined by a trial and error procedure.

Another problem encountered with the clarifiers at Vail was caused by a series of baffles that had been installed in the clarifiers. Four baffles had been placed in each clarifier with the intent of keeping the majority of the settled sludge in the head end of the clarifier. In actuality the baffles increased the flow velocity past each baffle (the cross-sectional area of the clarifier was decreased at that point) and hindered the settling of the activated sludge flow. Also, each baffle acted like a hydraulic "barrier" to inhibit pulling the sludge back to the head end of the clarifiers. The result of these "barriers" was to force sludge to accumulate in the weir overflow section of the clarifiers and aggrevate the sludge bulking problems. The baffles were removed and the sludge bulking problem was reduced substantially.

During the assistance project, various other modifications to plant operation were made and recommendations for future modifications were given. Modifications to control the return sludge flow rate, control of the waste sludge operation, measurement of the return sludge flow rate, measurement of the waste sludge flow rate, control of the aerator operation, and control of the waste sludge thickening unit were made during the assistance project. Suggestions for future modifications to control the vacuum filter operation were also made. Each of these modifications are briefly discussed in this report.

The modification to controlling the return sludge flow rate involved drastic changes in the operators approach. Prior to the assistance project, the rate of return sludge flow was varied to control sludge bulking. This approach was inadequate. During assistance, the return sludge flow rate varied throughout the day as the incoming flow rate varied and was varied from day to day based on results of the control tests. Direct control over the rate of return sludge flow was maintained and positive control over plant operation from this standpoint was achieved.

Modifications to procedures for wasting excess activated sludge were made. A method of determining the quantity of sludge to be wasted and a change in the location of the sludge wasting draw off point were initiated. Prior to the assistance project the quantity of sludge to be wasted was not used as a tool for plant operation. A specific volume of sludge was wasted each day based on the influent flow rate. Since this volume was wasted irrespective of its solids concentration the quantity of sludge wasted could vary significantly and drastically change the quantity of sludge in the activated sludge system. During assistance the quantity of sludge wasted was determined based on the results of the control tests. Both the volume and concentration of sludge wasted was included in the calculations. Using this method, complete control over the quantity of sludge in the activated sludge system was achieved disregarding the uncontrolled sludge bulking problems that existed. The location of the sludge wasting draw off point had to be changed after the plant mode of operation was switched from contact stabilization to conventional. Prior to assistance, sludge was wasted from aeration basins #2 and #3, the re-aeration zones of the contact stabilization mode of operation. After the mode of plant operation was changed to conventional the mixed liquor from aeration basins #2 and #3 was too thin for wasting. Initially attempts were made to waste return sludge using the return sludge pumps. This method resulted in decreasing the rate of return sludge flow to the head end of the aeration basins and an alternative method of sludge wasting had to be provided. An alternative method was provided by modifying the separate waste sludge pump piping arrangement so that return sludge could be directed to the separate waste sludge pump and wasted without disrupting the return flow to the head of the aeration basins.

Measurement of the return sludge flow rate was initiated by developing a flow chart for the four telescoping return sludge valves. Prior to assistance the four telescoping valves had been adjusted to control the rate of return sludge flow; however, the volume of sludge returned was not determined. No return sludge flow meters are provided at the Vail facility. During assistance an indication of the rate of flow of return sludge was made by determining the time required to fill a specific volume in the return sludge wet well and calculating the corresponding flow rate. Flow rates were determined for various settings of the telescoping valves and a graph showing the telescoping valve setting versus the flow rate was developed. This method of determining the rate of return sludge flow is satisfactory as an interim measure. It is recommended that future plant modifications include a return sludge flow meter in order to attain more precise return sludge flow measurements.

A method of measuring the waste sludge flow rate was also initiated. A waste sludge flow meter is provided at Vail, but was not calibrated properly at the time of assistance. During assistance the waste sludge flow rate was determined by measuring the time required to fill a specific volume in the sludge thickening unit. It is recommended that this method of determining the waste sludge flow rate be used until the available flow meter is properly calibrated.

Aerator operation was modified at the same time the plant mode of operation was switched from contact stabilization to conventional. The modifications involved changing the operation of the three surface mechanical aerators from an on-off time clock operation to a continuous operation. Prior to assistance various on-off time cycles for all three aerators were tried in order to improve plant effluent quality. During assistance all three aerators were operated continuously. It was felt that continuous operation would provide for better mixing conditions and better mixing would yield a higher quality plant effluent. It is recommended that all three surface mechanical aerators continue to be operated on a continuous basis.

The modification made concerning control of the sludge thickening operation involved adjusting the quantity of polymer added to the selected quantity of sludge entering the flotation unit. At Vail sludge is wasted to a flotation unit and a polymer is mixed with the wasted sludge causing the sludge to float and thicken. The supernatant (clear liquid) from the flotation is recycled to the aeration basins. An adequate quantity of polymer must be mixed with the sludge or a clear supernatant cannot be attained. When attempts were first made to waste sludge to the flotator, a clear supernatant could not be attained. The polymer feed rate was checked and was found to be inadequate due to a clogged line. After the line was flushed, adjustments were made in the quantity of polymer added to the flotator per quantity of sludge added to the flotator by adjusting the polymer concentration, polymer pump rate, polymer pump stroke, and sludge feed rate to the flotator. Prior to assistance, these adjustments were not varied and a consistently clear supernatant from the flotator could not be maintained. During assistance all adjustments were varied and a consistently clear supernatant was obtained. Time during the assistance project; however, did not permit an extensive analysis of the flotator portion of the sludge handling system. Additionally an extensive analysis was not made of the vacuum filter portion of the sludge handling system. In both cases suggestions regarding possible alternative investigations to optimize the sludge handling operation were given. It is recommended that investigations be continued to determine the most efficient operational method for both the sludge flotator unit and vacuum filter. The results of these investigations should give the methods of operation necessary to achieve the desired thickener and vacuum filter operation at the most economical cost.

C. PERFORMANCE RESULTS

Prior to the technical assistance project effluent water quality data was incomplete and questionable. During assistance, BOD_5 and suspended solids analyses were conducted on composited samples of plant influent and clarifier effluent each day. In addition turbidity tests were conducted on the clarified effluent seven times per day. After assistance BOD_5 analyses were conducted on composited samples of plant influent and clarifier effluent periodically, turbidity tests were conducted on the clarified effluent seven times per day, and the suspended solids analyses were conducted infrequently. For this report only the BOD_5 and turbidity data are discussed quantitatively.

Figure 2 shows the daily average turbidity values of the clarified effluent during and after the assistance project. It should be noted that in all cases attempts were made to exclude suspended solids in the turbidity sample. The purpose of the turbidity test was to indicate the ability of the mixed liquor suspended solids in the aeration basin to convert colloidal and dissolved BOD_5 in the waste stream to sludge solids. A high turbidity normally indicates a larger quantity of colloidal and dissolved BOD_5 present in the clarifier effluent and low turbidity normally indicates smaller quantities of colloidal and dissolved BOD_5 in the clarifier effluent. It is noted that a low turbidity value reported as outlined above does not necessarily mean low effluent total

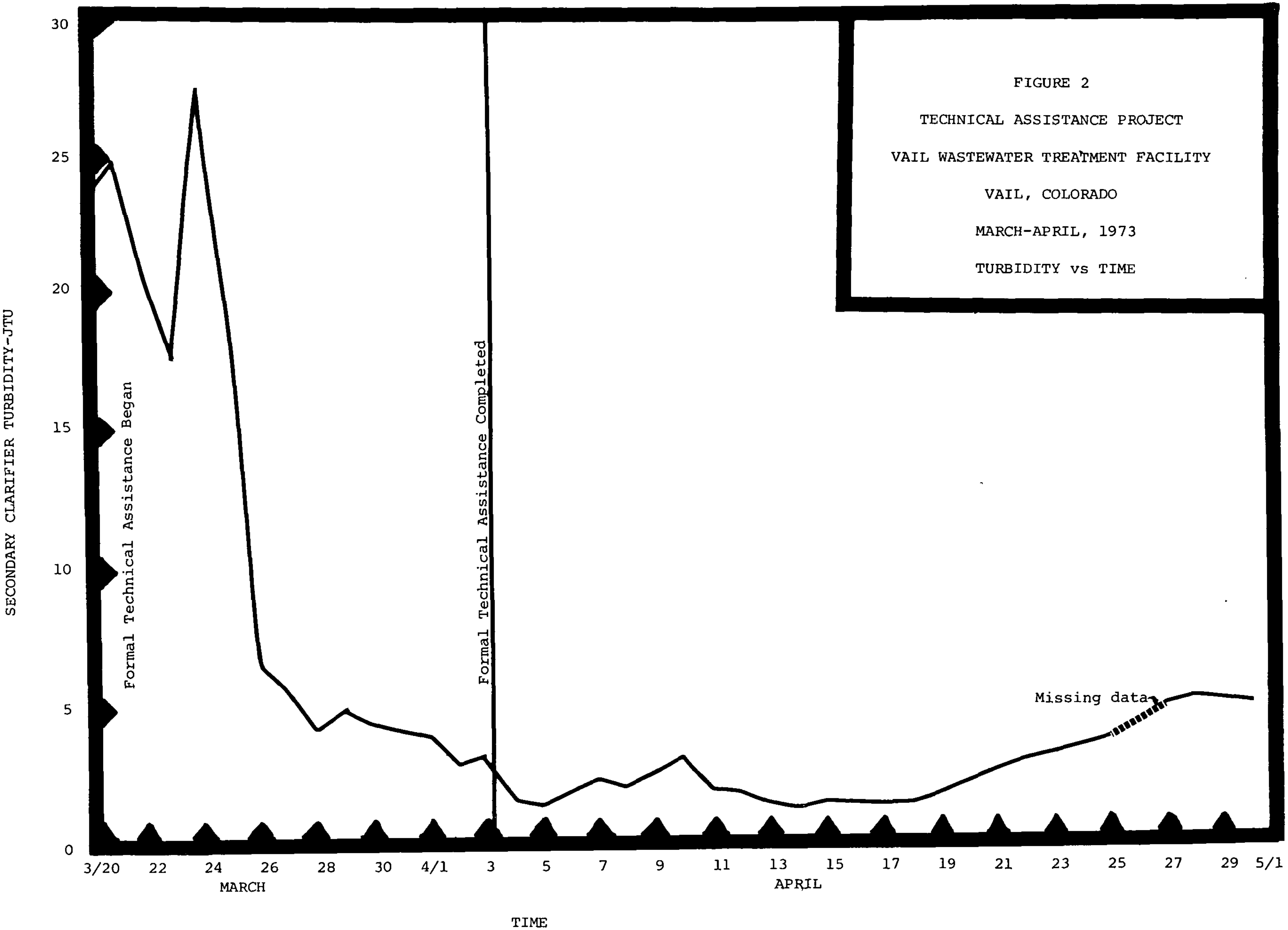
FIGURE 2
TECHNICAL ASSISTANCE PROJECT
VAIL WASTEWATER TREATMENT FACILITY
VAIL, COLORADO
MARCH-APRIL, 1973
TURBIDITY vs TIME
SECONDARY CLARIFIER TURBIDITY-JTU
30
25
20
15
10
5
0
Formal Technical Assistance Began
Formal Technical Assistance Completed
Missing data
3/20
22
24
26
28
30
4/1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
5/1
MARCH
APRIL
TIME

BOD_5 values because of the possible presence of suspended solids in the clarifier effluent.

Figure 2 shows a dramatic decrease in the turbidity within one week after the beginning of the assistance project and a continued decrease in turbidity until formal assistance was completed. The dramatic decrease in turbidity was the result of the changes in plant operation as discussed earlier in the report, (e.g. changed plant mode of operation, changed return sludge flow operation, changed aerator operator operation, etc.). The continued slower decrease in turbidity after the initial drop indicates the length of time required for the activated sludge biological system to change and develop. After the formal technical assistance project was completed the turbidity increased, then decreased, and then increased again. These changes in turbidity indicate the continued problems encountered with the final clarifiers and the resultant solids loss due to uncontrollable "sludge bulking". Sludge bulking occurred primarily because of inadequate flow distribution to the two final clarifiers. The uncontrolled solids loss caused lower MLSS concentrations resulting in additional colloidal and dissolved BOD5 in the plant effluent.

Figure 3 shows the daily composited secondary clarifier effluent BOD_5 test results. At the beginning of the assistance project most of the BOD_5 in the effluent was due to the colloidal and dissolved organic matter, (refer to Figure 2 for an indication of amount of colloidal and dissolved organic matter in the effluent as measured by turbidity). During assistance less of the BOD_5 was due to colloidal and dissolved organic matter and more of the BOD_5 was due to suspended solids "lost" in the effluent. As can be seen from Figure 3, a drastic reduction in the BOD_5 occurred during the assistance project (i.e. approximately 110 mg/l to 45 mg/l) and an even further reduction occurred after

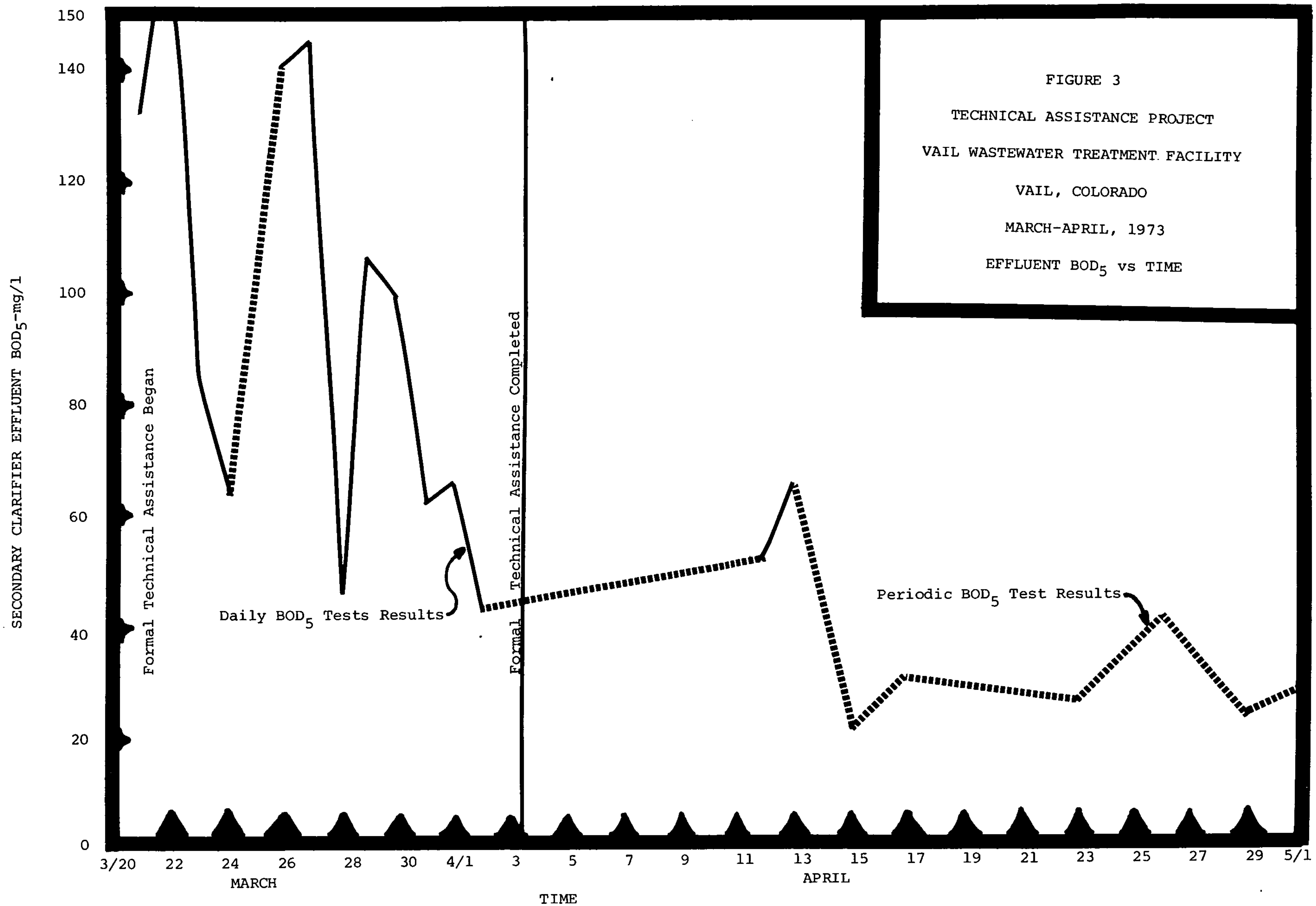

FIGURE 3

TECHNICAL ASSISTANCE PROJECT

VAIL WASTEWATER TREATMENT FACILITY

VAIL, COLORADO

MARCH-APRIL, 1973

EFFLUENT BOD$_5$ vs TIME

formal assistance was completed (i.e. approximately 45 mg/l to 30 mg/l). However, the present Colorado Water Quality BOD_5 Standard (30 mg/l) was not consistently being met. The primary reason this standard was not met was the continued problems associated with the final clarifier. If the problems with the final clarifiers are eliminated, it is felt that the Vail treatment facility will be capable of consistently discharging BOD_5 and suspended solids concentrations less than 30 mg/l.

The reduction in clarifier effluent BOD_5 due to technical assistance represents nearly a 73% reduction in BOD_5 or a reduction of about 136.2 Kg (300 lbs.) of BOD_5 per day in the effluent (assume average plant flow of 1,703 cu m/day (450,000 gal/day) during assistance). Figure 4 shows that the present reduction in BOD_5 through the Vail facility increased from about 45% to about 75% due to assistance.

Greater reductions can be expected with appropriate modifications to the secondary clarifiers.

V. SUMMARY AND CONCLUSIONS

Region VIII of the Environmental Protection Agency (EPA) received a letter from the Colorado Department of Health requesting assistance concerning the operation of the Vail Wastewater Treatment Facility. An initial evaluation of the Vail plant was made on October 26 and 27, 1972. Various plant deficiencies were observed during the initial evaluation and recommendations were made to correct the observed problems. After the plant had been modified, a formal technical assistance project was initiated on March 19, 1973.

During assistance, plant personnel were taught the proper techniques used in collecting, compositing, and storing wastewater samples for the BOD_5 and total

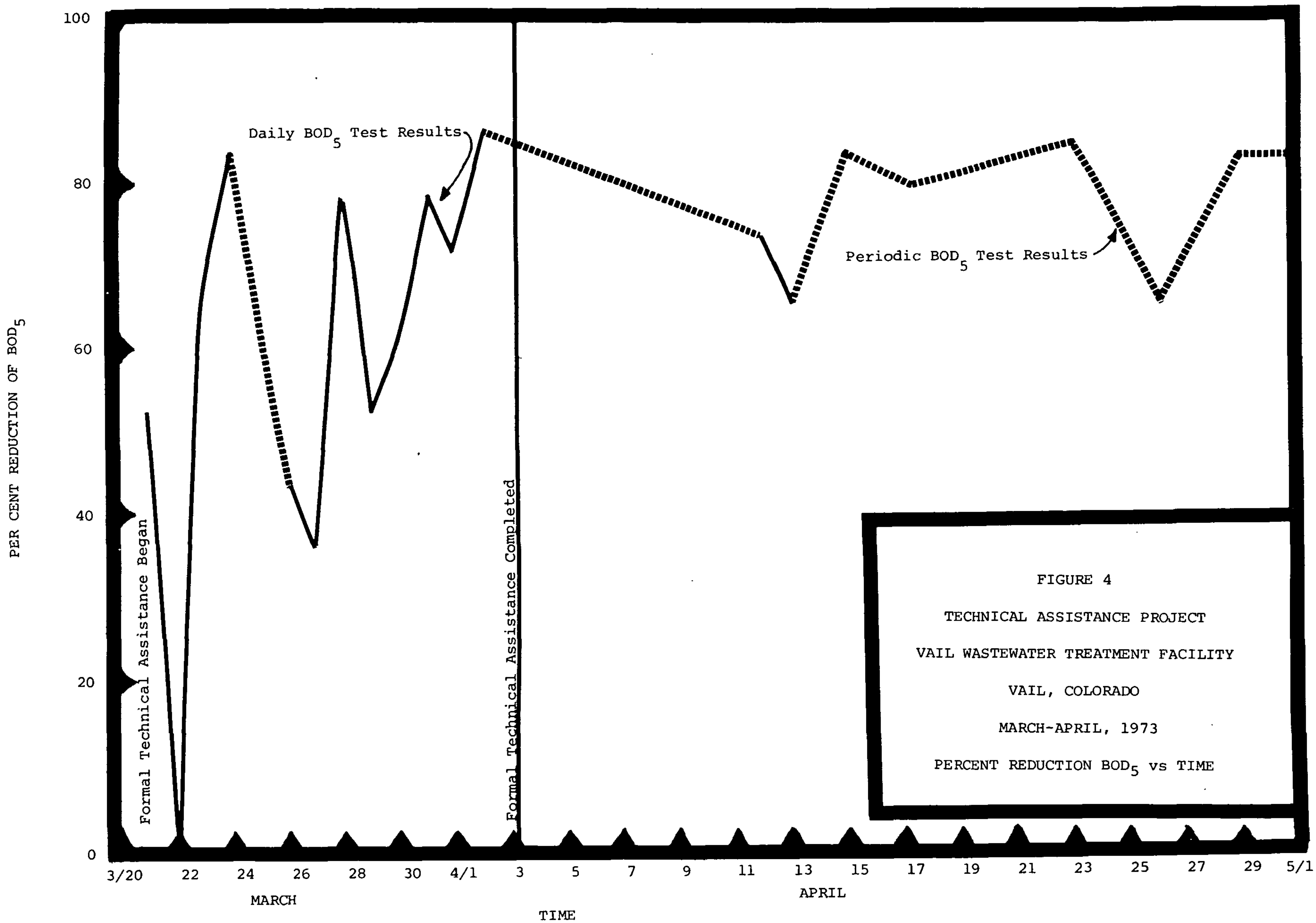

FIGURE 4

TECHNICAL ASSISTANCE PROJECT

VAIL WASTEWATER TREATMENT FACILITY

VAIL, COLORADO

MARCH-APRIL, 1973

PERCENT REDUCTION BOD_5 vs TIME

suspended solids analyses and were given instructions in the procedures used to run the BOD_5 and total suspended solids tests. However, limited manpower inhibited obtaining consistent analytical test results. Future plant considerations should include a position for a laboratory technician to insure consistent monitoring of plant performance by analytical tests.

Plant personnel were also given instructions in conducting and interpreting various "control" tests. Initiation of the control tests and data interpretation methods aided in solving problems encountered when controlling plant operation. The operators should be able to use these methods to solve future operational problems.

Prior to technical assistance, the Vail facility had been operated with the major emphasis on eliminating sludge bulking. As a result of this emphasis, little sludge bulking or loss of solids occurred, but effluent quality was not satisfactory. The procedures that had been used to control bulking resulted in low concentrations of sludge solids in contact with the sewage and ineffective conversion of colloidal and dissolved BOD_5 to "activated" sludge solids.

Numerous process modifications were made at the Vail plant in conjunction with the results of the control tests and data interpretation. The most significant modifications were the conversion from the contact stabilization mode to the conventional mode of activated sludge operation and the initiation of continuous aerator operation. As a result of these modifications, as well as others, effluent quality was substantially improved; however, optimum performance was not achieved due to various design deficiencies that existed.

Several plant deficiencies were corrected during the project including; the removal of baffles from the final clarifiers, the changing of the location for withdrawing waste or excess activated sludge, and the adjustment and cleaning of the polymer feed equipment. Other deficiencies which were noted were not modified during the project. These included the shallow rectangular final clarifiers which were designed to remove sludge by returning it to the head of the clarifiers (countercurrent to the sewage flow) and the inadequate method of splitting flow to the final clarifiers.

All modifications to the Vail facility combined to drastically reduce the clarifier effluent BOD_5 from about 110 mg/l to about 45 mg/l during assistance and to about 30 mg/l after formal assistance was completed. The percent reduction in BOD_5 through the plant increased from about 45% to about 75%. Even though the BOD_5 was reduced significantly, the Vail facility was not consistently meeting the Colorado Water Quality BOD_5 Standard of 30 mg/l. The primary reason why the BOD_5 standard was not met consistently was the continued problems associated with the secondary clarifiers. If these problems are eliminated, it is felt that the Vail facility will be capable of consistently discharging BOD_5 and suspended solids concentrations of less than 30 mg/l.

VI. RECOMMENDATIONS

Based on the results of the assistance project, the following recommendations are made:

1. Methods of operational control and control testing outlined during the assistance project should be continued.
2. The relationship between the Vail treatment facility and the Upper Eagle treatment facility should continue to include flow splitting capability so that the Upper Eagle facility can accept additional flow while the Vail facility is experiencing operational problems or the Vail facility can accept additional flow while the upper Eagle facility is experiencing operational problems.

3. All three surface mechanical aerators should be operated continuously.
4. Plant modifications should be made to provide for positive flow splitting capability to each final clarifier.
5. Lower flows should be accepted at the Vail facility to reduce the problems associated with the existing clarifiers. The maximum volume of flow that clarifiers are capable of accepting and adequately treating, should be determined by a trial and error procedure.
6. The clarifier capacity as established by a trial and error procedure should be considered in future designs if increased plant capacity is desired.
7. Plant modifications should be made to provide for more precise return sludge flow measurements.
8. The method of determining the waste sludge flow rate as established during assistance should be used until the waste sludge flow meter is properly calibrated.
9. Investigations should be continued to determine the optimum flotation unit and vacuum filter operation.
10. A separate laboratory technician should be considered to perform all analytical work. If one technician at Vail is not feasible, consideration should be given to sharing a technician with the Upper Eagle treatment facility.
11. The plant should be operated on a twenty-four hour basis to allow manual adjustments to the present flow splitting devices on the final clarifiers. This interim activity should continue until an adequate automatic flow splitting device can be installed.

REFERENCES

1. Standard Methods for the Examination of Water and Wastewater, 13th Edition, American Health Association, 1015 Eighteenth Street, N.W. Washington, D.C., 20036

2. Operation of Wastewater Treatment Plants, A Field Study Training Program, prepared by Sacramentao State College for the Environmental Protection Agency, Office of Water Programs, Division of Manpower and Training.