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ANALYSIS OF IMPACT OF BUSCH GARDENS EXPANSION ON AIR QUALITY OF SURROUNDING AREA

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ANALYSIS OF THE IMPACT OF THE PROPOSED BUSCH GARDENS DISPATCH ON THE ENVIRONMENTAL AIR QUALITY

I. Background

This report is concerned primarily with the increase in carbon monoxide concentrations and hydrocarbon concentrations induced by the projected increased traffic that would be associated with the parking facilities planned to support the expansion of Busch Gardens planned for the summer of 1976. The analysis has been conducted in accordance with the E.P.A. publication, AP101, "Guidelines for the Review of the Impact of Indirect Sources on Ambient Air Quality," January 1975. Of primary concern is the integrated effect of the increased traffic that will be handled by existing facilities and an enlarged parking lot across the highway from the main Busch Garden attraction. A map with a schematic representation of selected receptor sites plus existing and projected locations is shown in Figure 1.

The study addresses the specific problems outlined in a letter from the director of Region VI of the Virginia State Air Pollution Control Board to Mr. James Franklin. The pertinent requirements by the SAPCB are summarized in an extract paragraph from the subject letter given below.

"Inasmuch as the gardens/brewery complex comprises both a Direct and Indirect Source of significant size, we will also require measured air quality data at the proposed site, and an analysis of the impact that the proposed modification will have on the ambient air quality in the surrounding area. In order to minimize the magnitude of these requirements, measured air quality data may be limited to the measurement of carbon monoxide for a

period of not less than thirteen consecutive days to include two complete weekends when the gardens is open to the public (Thursday through Tuesday preferred). The analysis of the impact of the proposed modification on ambient air quality may be limited to the pollutants carbon monoxide and non-methane hydrocarbons."

In response to a request from Mr. James Franklin, the Old Dominion University Atmospheric Research Group agreed to conduct such an analysis which would include a field experiment as required by the State Air Pollution Control Board.

II. Methodology

A. For background concentrations the ODU Mobile Laboratory was moved to the Busch Gardens vicinity and conducted a 14-day field experiment collecting the following data: carbon monoxide, total hydrocarbon, non-methane hydrocarbon and methane, as well as meteorological data for the area. Since there were no long period statistics for carbon monoxide in the area of Busch Gardens, a technique was used to establish background concentrations in accordance with paragraph 4.30 of the E.P.A. Guidelines. The narrowness of the time window in which the investigation would be conducted included the last two weekends of Busch Gardens' operations for calendar year 1975. To offset possible instrument difficulties, duplicate carbon monoxide measurements were made using the following two instruments: 1) a Beckman Isotopic Absorption Infrared Analyzer and 2) an Equalizer CO Analyzer which uses a colorametric technique. To insure conservative analysis, the measurements for the highest values were used. The seasonal adjustment for these data was made in accordance with paragraph 4.31 of the E.P.A. Guidelines; and

normalized for the worst possible conditions on the basis of data extracted by the E.P.A. publication, AP 101, "Mixing Heights, Wind Speeds and Potential for Urban Air Pollution Throughout the Contiguous United States."

B. Ambient concentrations of carbon monoxide. The projected traffic induced concentrations were based on planned parking lot and roadway data provided by Busch Gardens and on projected traffic densities and traffic control statistics provided by Busch Gardens and the Virginia State Highway Department. The two receptor areas chosen for this study were:

a) Receptor 1 - Main entrance to Busch Gardens

b) Receptor 2 - At the Anheuser-Busch Hospitality Center

Two types of analyses were conducted for these locations. For the first receptor, concentration computations were made for both 1975 and for the projected conditions in 1976, permitting an analysis of the projected increase in concentration at this receptor. For the second receptor, the complete analysis of the projected concentrations for the highest one-hour period and the highest one-hour rate of concentration averaged over an eight-hour period was computed and added to the projected background concentrations deduced from the 14-day experiment and adjusted in accordance with E.P.A. Guidelines. The source areas for each of the receptor sites are shown in Figure 1.

III. Computed Contributions of Projected and Existing Sources.

Tables 1 and 2 contain computation data for Receptor 1 and Table 3 contains computation data for Receptor 2. Road segments

1 and 3 (R1 and R3) are pertinent to the computation of ambient concentrations while road segments 2 and 4 (R2 and R4) are pertinent to Receptor 2 (see Figure 1). Note that road segments 1 and 2 are on Route 60 while road segments 3 and 4 are on Route 143.

Figure 1 is the map of the immediate area of Busch Gardens and the proposed expanded parking lot showing the two primary roads; viz., Route 60 (road segments 1 and 2) and Route 143 (road segments 3 and 4).

Although there are (existing and proposed) other traffic lights on Route 60, the one that will most effect the flow in the area will be located at the entrance to Lot e. Traffic from the Hampton Roads region will be traveling east to west on Route 143 and merges with traffic from the north traveling west to east on Route 60. Since this traffic will not transverse road segment 2 if it enters either Lot E or the expanded lot, Receptor 1 had to be handled differently than Receptor 2.

In Tables 1 and 2 (values for Receptor 1), lanes 1 and 2 of road segment 2 are the east bound lanes of Route 60 and lanes 3 and 4 are west bound. Lanes 1 and 2 of road segment 4 and lanes 3 and 4 are east bound and west bound respectively.

The appropriate graphs in the E.P.A. Guidelines, which were used in calculating the CO concentrations, were determined according to the type of roadway (see Tables 1, 2 and 3). The distance to receptor is the perpendicular distance between the receptor and the nearest edge of a traffic lane. For a lane width of twelve feet, at these distances, distinction between the distance of individual lanes is unnecessary. The one exception was in the cal-

culation of the concentration at 10 meters for the parking lot entrance for Receptor 2 concentrations.

The maximum design capacity and the average daily traffic have been supplied by the Virginia Department of Highways. The maximum one-hour traffic is normally around 10% of the twenty-four hour total and the maximum eight hour is normally around 50% of the total. In this case, available one-hour readings showed the maximum one-hour for the day for all lanes was between ten and eleven in the morning. The numbers in column 6 of the table indicate the maximum for any hour of the day. For example, in the calculation of the effect on Receptor 2, it is inconceivable that 1,505 vehicles will be both entering and leaving the lot in any one hour. Rather, 1,505 vehicles per hour would be expected to leave late in the evening.

Actual traffic counts in the area of Busch Gardens indicated that the maximum eight-hour traffic was closer to 60% of the daily total, which was the basis used to derive all eight-hour maxima.

In heavy traffic, an actuated traffic light will allow for the highest green time to cycle time ratio (G/Cy) for each lane of an intersection. On Route 60, it was assumed that the average speed would be 35 MPH and that the east bound lane would receive a green light for 45 seconds; in addition, the two lanes for a left turn into the parking lot would receive an additional 25 seconds. The volume demand to capacity (V/C) ratio is derived from the tables in the E.P.A. Guidelines manual.

In the Tables 1, 2 and 3, columns 9 and 14 show the concentration at ten meters from the edge of the source. The figure number

of the appropriate graph in the E.P.A. Guidelines is given in column 10.

Column 11 is the relative concentration at the receptor which, when multiplied by the one-hour and eight-hour concentrations at ten meters, yields the maximum one-hour and eight-hour concentrations (Column 12 and 15) at the receptor.

To allow for the effect of increased number of vehicles with pollution control, the sum of the values in columns 1, 2 and 3 are multiplied by 0.9, which is the 1976 reduction figure. The calculations for Receptor 2 also involve the traffic at the lot entrance, which includes the buses which carry the people to and from the Gardens as well as local traffic. The traffic at the lot exit is estimated by using the capacities of both Lot E and the proposed expanded lot plus allowance for a 20% turnover in a one-day period. This number is the highest expected turnover based on 1975 ticket sales to the Garden and the average of 3.5 people per car.

The concentration value for the parking lot exit is multiplied by a cold start factor for 100% cold starts, while the value for the lot entrance assumes a 0% of cold starts. These figures are added to the values in column 15. This number is in turn multiplied by a meteorological persistance factor of 0.6 in accordance with E.P.A. Guidelines to yield the average one-hour increase during the maximum eight-hour period.

IV. Computed Background - Concentrations

A. Hydrocarbon Concentrations:

The non-methane hydrocarbons were rather high during the entire field experiment period. This presents a special analysis problem which will be discussed in the next section.

B. Carbon Monoxide Concentrations:

Tables 4 through 16 show the average hourly CO concentrations as measured by the ODU Mobile Laboratory. The carbon monoxide values are the average of the concentrations made by the two distinct sensors described in section II above. These data show that the highest one-hour average value is 10.0 parts per million, and the average one-hour concentration rate averaged over an eight-hour period is 6.75 parts per million.

To compute the seasonal adjustment for these figures in accordance with E.P.A. Guidelines, the following formula was used to compute maximum background concentration (x_b):

$$x_b = \frac{\text{Max. obs. 1- or 8 hr. conc. @ applicant's site during source operating hours}}{\text{Maximum } \bar{x}/\bar{Q} \text{ from AP-101}} \times \frac{\text{Maximum } \bar{x}/\bar{Q} \text{ from AP-101}}{\bar{x}/\bar{Q} \text{ from AP-101 during time of year in which monitoring is performed}}$$

$\bar{x}/\bar{Q}$ equals the upper decile of the ratio of the average concentration value to the average emission rate for the season (see AP 101).

Since the highest value of the ratios selected from the E.P.A. report, AO 101, shows the fall season to have the highest seasonal values, the estimated seasonal background value is equal to the one-hour average and eight-hour average values measured by the ODU Mobile Laboratory.

V. Integrated Results

A. Hydrocarbon Concentration:

The observed hydrocarbon rates were high (see Figures 4-16) and frequently above the national standard levels, i.e., the national standard requires the concentration of non-methane hydrocarbons for a three-hour period between six and nine AM each morning to be below 0.24 parts per million. Since the contributions from the Busch Gardens facility will not begin until after nine o'clock, they would not contribute in any way to changing the concentrations for this period.

Unquestionably, there will be a contribution to the hydrocarbon levels during the remainder of the day from the traffic sources in the area. The Mobile Laboratory data suggests that this problem should be studied further in a more exhaustive treatment. Analysis of the data presented here suggests many sources for the hydrocarbon mixture including a sewage disposal plant located to the west of the field experiment site. On at least two of the occasions of high hydrocarbons, the diurnal pattern suggested that they were advected in the upper levels during the night from another region and fumigated down to the surface when the increased instability of the day set on with diurnal heating.

B. Carbon Monoxide Concentration:

From the results described in the previous section, data from the first receptor showed a one-hour and eight-hour increase of only .08 and .03 parts per million respectively, that would be induced by the projected increased traffic and traffic facilities.

For the second receptor, located at the Hospitality Center, the combination of the background data and the computed contributions from the projected expansion give a projected maximum one-hour concentration of 12.8 parts per million and a projected one-hour concentration rate averaged over an eight-hour period of 7.4 parts per million.

VI. Conclusions - Regional

In this screening type analysis, the magnitude of the contribution from the expanded facilities in conjunction with the estimated background concentrations would indicate that the impact of the expansion would not significantly effect the regional air quality with respect to carbon monoxide.

Local Environment

A. Hydrocarbon Concentration

The national hydrocarbon standard requires that the three-hour average of concentration between six o'clock AM and nine o'clock AM not exceed .24 parts per million. Since the Busch Gardens complex does not open until ten o'clock AM, their operation cannot possibly contribute to local concentrations exceeding the national standard.

B. Carbon Monoxide Concentration

The projected one-hour average and eight-hour average values of 12.8 parts per million and 7.4 parts per million respectively, are sufficiently below the E.P.A. standards of 35 parts per million and 10 parts per million respectively and suggest that the expansion will not contaminate the air quality beyond the E.P.A. and State of Virginia guidelines.

FIG. 1

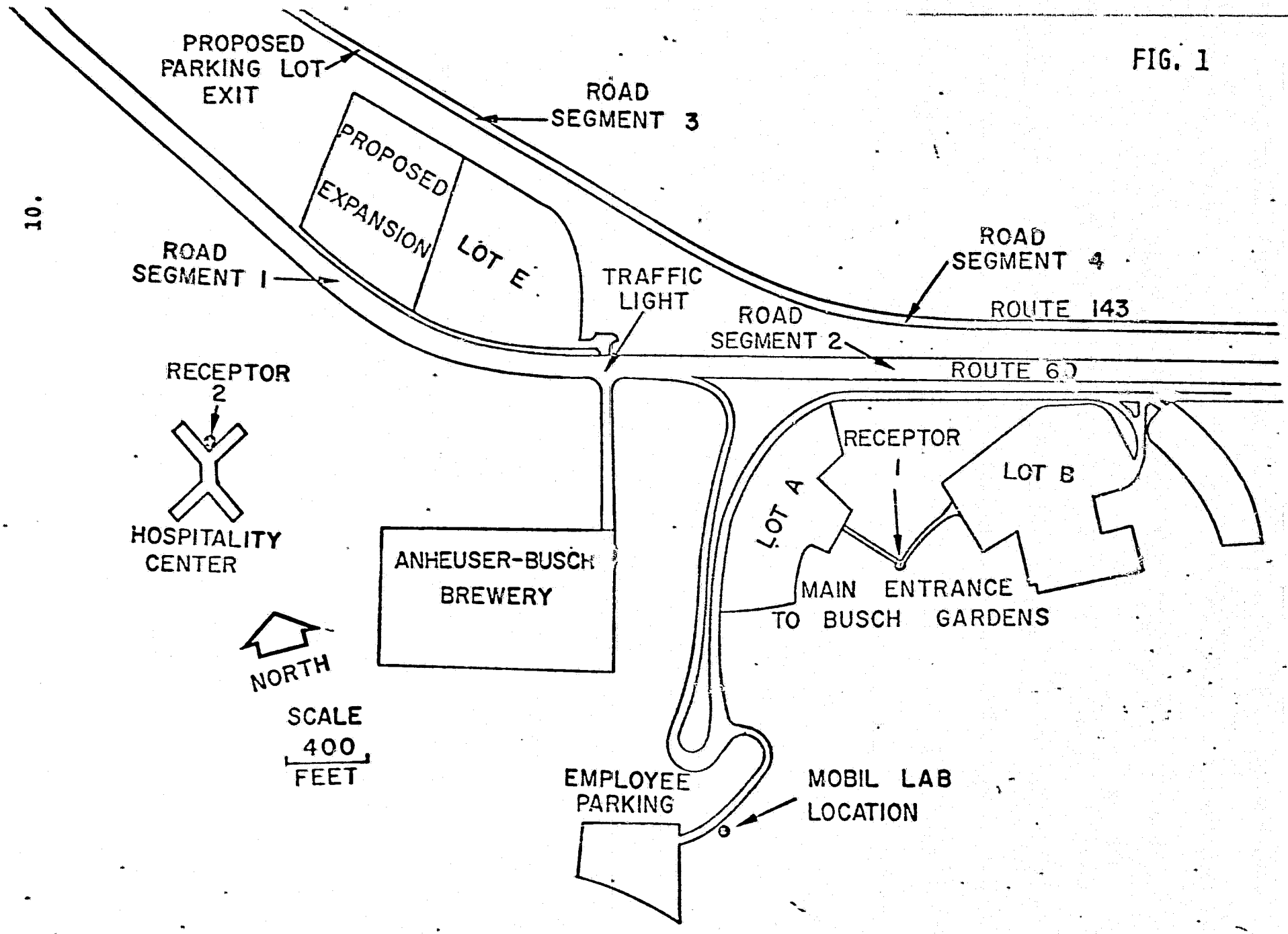
PROPOSED PARKING LOT EXIT
ROAD SEGMENT 3
PROPOSED EXPANSION
LOT E
ROAD SEGMENT 1
TRAFFIC LIGHT
ROAD SEGMENT 4
ROUTE 143
ROAD SEGMENT 2
ROUTE 64
RECEPTOR 2
HOSPITALITY CENTER
ANHEUSER-BUSCH BREWERY
RECEPTOR 1
LOT A
LOT B
MAIN ENTRANCE TO BUSCH GARDENS
NORTH
SCALE 400 FEET
EMPLOYEE PARKING
MOBIL LAB LOCATION

TABLE 1

RECEPTOR # 1
(1975)

1 Source (Road and Lane)	2 Type of Road way	3 Distance to Receptor (meters)	4 Maximum Design Capacity (vph)	5 Average Daily Traffic (vch)	6 Max 1 hr Traffic (vph)	7 Max 8 hr Traffic (vph)	8 Traffic Flow G/Cy	V/C	9 Conc. at 10 meters (PPM)	10 EPA Guideline Reference
R2										
Lane 1	MSD	274	2000	4380	436	2628	--	--	3.4	Fig 7
Lane 2	MSD	278	2000	4380	436	2628	--	--	3.4	Fig 7
Lane 3	MSU	282	2000	4810	481	2886	0.38	--	11.4	Fig 6
Lane 4	MSU	286	2000	4810	481	2886	0.38	--	11.4	Fig 6
R4										
Lane 1	MS	343	2000	553	100	330	--	0.05	1.0	Fig 3
Lane 2	MS	347	2000	553	100	330	--	0.05	1.0	Fig 3
Lane 3	MS	351	2000	2544	286	1525	--	0.14	1.6	Fig 3
Lane 4	MS	355	2000	2544	286	1525	--	0.14	1.6	Fig 3

Sum of col. 12 = 1.50 PPM (Maximum 1 hour)

Sum of col. 15 = 1.34 PPM
x0.6 (Persistance factor)
0.80PPM (1 hour concentration for max. 8 ho

MS = Major Street
MSD = Major Street, Downstream of light
MSU = Major Street, Upstream of light
IS = Indirect Source

RECEPTOR #1
(1975)

6 Max 1 hr Traffic (vph)	7 Max 8 hr Traffic (vph)	8 Traffic Flow G/Cy	V/C	9 Conc. at 10 meters (PPM)	10 EPA Guideline Reference	11 Relative Conc. at Receptor	12 Contrib. to Conc. at Receptor 1 hr (PPM)	13 Hourly Vol (Max. 8 hr	14 Conc. at 10 meters (PPM)	15 Contribution to concent. at Receptor (8 hr) PPM
36	2628	--	--	3.4	Fig 7	0.06	0.20	329	2.8	0.17
36	2628	--	--	3.4	Fig 7	0.06	0.20	329	2.8	0.17
81	2886	0.38	--	11.4	Fig 6	0.03	0.34	361	10.8	0.32
81	2886	0.38	--	11.4	Fig 6	0.03	0.34	361	10.8	0.32
00	330	--	0.05	1.0	Fig 3	0.08	0.08	41	1.0	0.08
00	330	--	0.05	1.0	Fig 3	0.08	0.08	41	1.0	0.08
86	1525	--	0.14	1.6	Fig 3	0.08	0.13	191	1.3	0.10
86	1525	--	0.14	1.6	Fig 3	0.08	0.13	191	1.3	0.10

.. 12 = 1.50 PPM (Maximum 1 hour)

.. 15 = 1.34 PPM
x0.6 (Persistance factor)
0.80PPM (1 hour concentration for max. 8 hours)

FOLDOUT FRAME 2

TABLE 2

RECEPTOR # 1
(Projected 1976)

1 Source (Road and Lane)	2 Type of Road way	3 Distance to Receptor (meters)	4 Maximum Design Capacity (vph)	5 Average Daily Traffic (vch)	6 Max 1 hr Traffic (vph)	7 Max 8 hr Traffic (vph)	8 Traffic Flow G/Cy	8 Traffic Flow V/C	9 Conc. at 10 meters (PPM)	10 EPA Guideline Reference
R2										
Lane 1	MSD	274	2000	4910	500	2946	--	--	3.75	Fig 7
Lane 2	MSD	278	2000	4910	500	2946	--	--	3.75	Fig 7
Lane 3	MSU	282	2000	5060	506	3036	0.38	--	14.40	Fig 6
Lane 4	MSU	286	2000	5060	506	3036	0.38	--	14.40	Fig 6
R4										
Lane 1	MS	343	2000	580	105	348	--	0.05	1.0	Fig 3
Lane 2	MS	347	2000	580	105	348	--	0.05	1.0	Fig 3
Lane 3	MS	351	2000	2670	300	1600	--	0.15	1.7	Fig 3
Lane 4	MS	355	2000	2670	300	1600	--	0.15	1.7	Fig 3

Sum of col. 12 = 1.76 ppm
x0.9 (1976 allowance)
1.58 ppm (maximum 1 hour)

Sum of col. 15 = 1.42 ppm
x0.9 (1976 allowance)
x0.6 (persistance factor)
0.77 ppm (1 hour concentration for maximum

MS = Major Street
MSD = Major Street, Downstream of light
MSU = Major Street, Upstream of light
IS = Indirect Source

FOLDOUT FRAME 4

RECEPTOR # 1
(Projected 1976)

6 ax hr raffic vph)	7 Max 8 hr Traffic (vph)	8 Traffic Flow G/Cy	V/C	9 Conc. at 10 meters (PPM)	10 EPA Guideline Reference	11 Relative Conc. at Receptor	12 Contrib. to Conc. at Receptor 1 hr (PPM)	13 Hourly Vol (Max. 8 hr	14 Conc. at 10 meters (PPM)	15 Contribution to concent. at Receptor (8 hr) PPM
500	2946	--	--	3.75	Fig 7	0.06	0.23	368	3.0	0.18
500	2946	--	--	3.75	Fig 7	0.06	0.23	368	3.0	0.18
506	3036	0.38	--	14.40	Fig 6	0.03	0.43	380	11.5	0.35
506	3036	0.38	--	14.40	Fig 6	0.03	0.43	380	11.5	0.35
105	348	--	0.05	1.0	Fig 3	0.08	0.08	44	1.0	0.08
105	348	--	0.05	1.0	Fig 3	0.08	0.08	44	1.0	0.08
300	1600	--	0.15	1.7	Fig 3	0.08	0.14	200	1.3	0.10
300	1600	--	0.15	1.7	Fig 3	0.08	0.14	200	1.3	0.10

1. 12 = 1.76 ppm
x0.9 (1976 allowance)
1.58 ppm (maximum 1 hour)

1. 15 = 1.42 ppm
x0.9 (1976 allowance)
x0.6 (persistance factor)
0.77 ppm (1 hour concentration for maximum 8 hours)

FOLDOUT FRAME 2

TABLE 3

RECEPTOR # 2 (Projected 1976)

1 Source (Road and Lane)	2 Type of Road way	3 Distance to Receptor (meters)	4 Maximum Design Capacity (vph)	5 Average Daily Traffic (vch)	6 Max 1 hr Traffic (vph)	7 Max 3 hr Traffic (vph)	8 Traffic Flow G/Cy	V/C	9 Conc. at 10 meters (PPM)	10 EPA Guideline Reference
R1 East Bound	MSU	285	4000	13,100	2200	7860	0.63	--	30.0	Fig 6
R1 West Bound	MSD	293	4000	10,400	1012	6240	--	--	6.7	Fig 7
R3 East Bound	MS	579	4000	1,160	210	696	--	0.05	1.0	Fig 3
R3 West Bound	MS	587	4000	5,340	600	3200	--	0.15	1.7	Fig 3
Lot Entra.	IS	549	2000	3,600	1505	2160	--	0.75	18.0	Fig 9
Lot Exit	IS	427	2000	2,751	1505	1661	--	0.75	14.2	Fig 4

MS = Major Street
MSU = Major Street, upstream of light
MSD = Major Street, downstream of light
IS = Indirect Source

Lot Entrance Conc. = 0.54 PPM (1 hour)
x 0.7 (cold start factor)
0.38 PPM

Lot Exit Conc. = 0.85 PPM (1 hour)
x 1.4 (cold start factor)
1.19 PPM

Sum of col. 12 = 3.09 PPM
x 0.9 (1976 allowance)
2.78 PPM (maximum ½ hour)

RECEPTOR # 2 (Projected 1976)

6 Max 1 hr Traffic (vph)	7 Max 8 hr Traffic (vph)	8 Traffic Flow G/Cy	V/C	9 Conc. at 10 meters (PPM)	10 EPA Guideline Reference	11 Relative Conc. at Receptor	12 Contrib. to Conc. at Receptor 1 hr (PPM)	13 Hourly Vol (Max. 8 hr	14 Conc. at 10 meters (PPM)	15 Contribution to concent. at Receptor (8 hr) PPM
2200	7860	0.63	--	30.0	Fig 6	0.03	0.90	983	13.9	0.42
1012	6240	--	--	6.7	Fig 7	0.06	0.40	780	5.3	0.32
210	696	--	0.05	1.0	Fig 3	0.08	0.08	87	1.0	0.08
600	3200	--	0.15	1.7	Fig 3	0.08	0.14	400	1.3	0.10
1505	2160	--	0.75	18.0	Fig 9	0.03	0.54	270	5.5	0.17
1505	1661	--	0.75	14.2	Fig 4	0.06	0.85	208	2.0	0.12

= 0.54 PPM (1 hour)
x 0.7 (cold start factor)
0.38 PPM

= 0.85 PPM (1 hour)
x 1.4 (cold start factor)
1.19 PPM

= 3.09 PPM
x 0.9 (1976 allowance)
2.78 PPM (maximum 1 hour)

Lot Entrance Conc. = 0.17 PPM (8 hour)
x 0.7 (Cold start factor)
0.12 PPM

Lot Exit Conc. = 0.12 PPM (8 hour)
x 1.4 (Cold start factor)
0.17 PPM

Sum of col. 15 = 1.21 PPM
x 0.9 (1976 allowance)
x 0.6 (Persistance factor)
0.65 PPM (1 hr conc. for max 8 hr)

FOLDOUT FRAME 2

BUSCH GARDENS EXPERIMENT
OLD DOMINION UNIVERSITY
AIR POLLUTION RESEARCH GROUP

OCTOBER 16 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	9	-9	-9	-9
1 - 2	6	-9	-9	-9
2 - 3	6	-9	-9	-9
3 - 4	2	-9	-9	-9
4 - 5	1	-9	-9	-9
5 - 6	2	-9	-9	-9
6 - 7	3	-9	-9	-9
7 - 8	3	-9	-9	-9
8 - 9	2	-9	-9	-9
9 - 10	1	-9	-9	-9
10 - 11	1	-9	-9	-9
11 - 12	2	-9	-9	-9
12 - 13	2	-9	-9	-9
13 - 14	4	-9	-9	-9
14 - 15	5	-9	-9	-9
15 - 16	8	-9	-9	-9
16 - 17	8	-9	-9	-9
17 - 18	6	-9	-9	-9
18 - 19	6	-9	-9	-9
19 - 20	7	-9	-9	-9
20 - 21	6	-9	-9	-9
21 - 22	6	-9	-9	-9
22 - 23	6	-9	-9	-9
23 - 24	6	-9	-9	-9
AVERAGE VALUES	4.5	0	0	0
MAXIMUM VALUE	9	0	0	0

BUSCH GARDENS EXPERIMENT
OLD DOMINION UNIVERSITY
AIR POLLUTION RESEARCH GROUP

OCTOBER 17 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	6	-9	-9	-9
1 - 2	7	-9	-9	-9
2 - 3	7	-9	-9	-9
3 - 4	3	-9	-9	-9
4 - 5	3	-9	-9	-9
5 - 6	2	-9	-9	-9
6 - 7	3	-9	-9	-9
7 - 8	3	-9	-9	-9
8 - 9	4	-9	-9	-9
9 - 10	4	-9	-9	-9
10 - 11	3	-9	-9	-9
11 - 12	2	-9	-9	-9
12 - 13	3	-9	-9	-9
13 - 14	2	-9	-9	-9
14 - 15	3	-9	-9	-9
15 - 16	3	-9	-9	-9
16 - 17	2	-9	-9	-9
17 - 18	1	-9	-9	-9
18 - 19	1	-9	-9	-9
19 - 20	4	-9	-9	-9
20 - 21	4	2.9	0.43	3.33
21 - 22	4	2.75	0.35	3.1
22 - 23	4	2.65	0.35	3
23 - 24	4	2.59	0.27	2.86
AVERAGE VALUES	3.41667	2.7225	0.35	3.0725
MAXIMUM VALUE	7	2.9	0.43	3.33

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OCTOBER 18 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	6	2.56	0.33	2.89
1 - 2	6	2.54	0.27	2.81
2 - 3	5	2.51	0.23	2.74
3 - 4	7	2.55	0.26	2.81
4 - 5	7	2.49	0.27	2.76
5 - 6	7	2.54	0.27	2.81
6 - 7	8	2.62	0.2	2.82
7 - 8	6	2.71	0.36	3.07
8 - 9	7	2.66	0.52	3.18
9 - 10	7	2.71	0.69	3.4
10 - 11	2	1.98	0.24	2.22
11 - 12	6	2.21	0.35	2.56
12 - 13	6	2.37	0.34	2.71
13 - 14	5	2.41	0.24	2.65
14 - 15	4	2.36	0.2	2.56
15 - 16	3	2.27	0.35	2.62
16 - 17	4	1.93	1.38	3.31
17 - 18	7	2.49	0.67	3.16
18 - 19	6	2.54	0.75	3.29
19 - 20	6	2.65	0.4	3.05
20 - 21	-9	-9	-9	-9
21 - 22	-9	-9	-9	-9
22 - 23	-9	-9	-9	-9
23 - 24	-9	-9	-9	-9
AVERAGE VALUES	5.75	2.455	0.416	2.871
MAXIMUM VALUE	8	2.71	1.38	3.4

BUSCH GARDENS EXPERIMENT
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OCTOBER 19 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	-9	-9	-9	-9
1 - 2	-9	-9	-9	-9
2 - 3	-9	-9	-9	-9
3 - 4	-9	-9	-9	-9
4 - 5	-9	-9	-9	-9
5 - 6	-9	-9	-9	-9
6 - 7	-9	-9	-9	-9
7 - 8	-9	-9	-9	-9
8 - 9	-9	-9	-9	-9
9 - 10	-9	-9	-9	-9
10 - 11	10	2.31	0.4	2.71
11 - 12	5	2.3	0.4	2.7
12 - 13	6	2.42	0.58	3.
13 - 14	7	2.4	0.49	2.89
14 - 15	8	2.31	0.36	2.67
15 - 16	4	2.33	0.36	2.69
16 - 17	5	2.3	0.36	2.66
17 - 18	4	2.32	0.35	2.67
18 - 19	5	2.44	0.65	3.09
19 - 20	5	2.45	0.49	2.94
20 - 21	1	2.28	0.36	2.64
21 - 22	0	2.31	0.29	2.6
22 - 23	0	2.67	0.88	3.55
23 - 24	1	3.38	1.26	4.64
AVERAGE VALUES	4.35714	2.44429	0.516429	2.96071
MAXIMUM VALUE	10	3.38	1.26	4.64

BUSCH GARDENS EXPERIMENT
OLD DOMINION UNIVERSITY
AIR POLLUTION RESEARCH GROUP

OCTOBER 20 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	0	3.09	1.15	4.24
1 - 2	1	2.64	0.12	2.76
2 - 3	1	2.45	0.35	2.8
3 - 4	2	2.62	0.35	2.97
4 - 5	0	2.7	0.44	3.14
5 - 6	0	2.81	0.42	3.23
6 - 7	0	2.81	1	3.81
7 - 8	0	2.47	0.38	2.85
8 - 9	0	2.99	0.42	3.41
9 - 10	0	3.02	0.38	3.4
10 - 11	1	2.94	0.39	3.33
11 - 12	1	2.92	0.38	3.3
12 - 13	1	2.76	0.25	3.01
13 - 14	1	2.77	0.27	3.04
14 - 15	0	2.76	0.27	3.03
15 - 16	1	2.84	0.25	3.09
16 - 17	0	2.84	0.18	3.02
17 - 18	0	2.74	0.25	2.99
18 - 19	0	2.7	0.24	2.94
19 - 20	1	2.82	0.33	3.15
20 - 21	1	3.01	0.3	3.31
21 - 22	0.5	3	0.35	3.35
22 - 23	0.5	3.06	0.42	3.48
23 - 24	0.5	3.36	0.24	3.6
AVERAGE VALUES	0.520833	2.83833	0.380417	3.21875
MAXIMUM VALUE	2	3.36	1.15	4.24

BUSCH GARDENS EXPERIMENT
OLD DOMINION UNIVERSITY
AIR POLLUTION RESEARCH GROUP

OCTOBER 21 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	0	3.23	0.69	3.92
1 - 2	0.5	3.07	0.52	3.59
2 - 3	1	3.24	0.59	3.83
3 - 4	1	3.33	0.6	3.93
4 - 5	1	3.45	0.53	3.98
5 - 6	1	3.21	0.64	3.85
6 - 7	1	3.15	0.67	3.82
7 - 8	1.5	3.25	0.68	3.93
8 - 9	1	3.23	0.69	3.92
9 - 10	1	3.2	0.73	3.93
10 - 11	1	3.25	0.83	4.08
11 - 12	0.5	3.49	1.1	4.59
12 - 13	1	2.97	0.62	3.59
13 - 14	1	2.74	0.4	3.14
14 - 15	1.5	2.75	0.43	3.18
15 - 16	1	2.64	0.49	3.13
16 - 17	1	2.74	0.59	3.33
17 - 18	1	2.69	0.55	3.24
18 - 19	1	2.82	0.62	3.44
19 - 20	1	2.77	0.56	3.33
20 - 21	0.5	2.77	0.57	3.34
21 - 22	0.5	2.82	0.62	3.44
22 - 23	0.5	2.87	0.71	3.58
23 - 24	0.5	2.82	0.63	3.45
AVERAGE VALUES	0.875	3.02083	0.6275	3.64833
MAXIMUM VALUE	1.5	3.49	1.1	4.59

BUSCH GARDENS EXPERIMENT
OLD DOMINION UNIVERSITY
AIR POLLUTION RESEARCH GROUP

OCTOBER 22 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	1	3	0.85	3.85
1 - 2	1	3.07	0.9	3.97
2 - 3	0.5	3.06	0.88	3.94
3 - 4	0.5	2.99	0.81	3.8
4 - 5	0.5	3.02	0.82	3.84
5 - 6	1	3.07	0.8	3.87
6 - 7	1	3.07	0.8	3.87
7 - 8	1	3.23	0.85	4.08
8 - 9	1	3.14	0.86	4
9 - 10	1.5	3.09	0.9	3.99
10 - 11	1	3.34	1.1	4.44
11 - 12	1	3.16	1.01	4.17
12 - 13	1	3.09	1	4.09
13 - 14	1	2.92	0.92	3.84
14 - 15	1	2.91	1.06	3.97
15 - 16	-9	3.01	0.93	3.94
16 - 17	-9	-9	-9	-9
17 - 18	-9	-9	-9	-9
18 - 19	-9	-9	-9	-9
19 - 20	-9	-9	-9	-9
20 - 21	-9	-9	-9	-9
21 - 22	0.5	3	1.23	4.23
22 - 23	0.5	3.36	1.23	4.59
23 - 24	0.5	3.54	1.38	4.92
AVERAGE VALUES	0.861111	3.10895	0.964737	4.07368
MAXIMUM VALUE	1.5	3.54	1.38	4.92

BUSCH GARDENS EXPERIMENT
OLD DOMINION UNIVERSITY
AIR POLLUTION RESEARCH GROUP

OCTOBER 23 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	1	3.64	1.42	5.06
1 - 2	1	4.08	1.55	5.63
2 - 3	1	-9	-9	-9
3 - 4	1	-9	-9	-9
4 - 5	1	-9	-9	-9
5 - 6	1	-9	-9	-9
6 - 7	1	-9	-9	-9
7 - 8	2	-9	-9	-9
8 - 9	4	-9	-9	-9
9 - 10	5	-9	-9	-9
10 - 11	8	-9	-9	-9
11 - 12	9	-9	-9	-9
12 - 13	7	-9	-9	-9
13 - 14	6	-9	-9	-9
14 - 15	3	-9	-9	-9
15 - 16	2	-9	-9	-9
16 - 17	3	-9	-9	-9
17 - 18	3	-9	-9	-9
18 - 19	3	-9	-9	-9
19 - 20	3	-9	-9	-9
20 - 21	6	-9	-9	-9
21 - 22	6	-9	-9	-9
22 - 23	6	-9	-9	-9
23 - 24	5	-9	-9	-9
AVERAGE VALUES	3.66667	3.86	1.485	5.345
MAXIMUM VALUE	9	4.08	1.55	5.63

BUSCH GARDENS EXPERIMENT
OLD DOMINION UNIVERSITY
AIR POLLUTION RESEARCH GROUP

OCTOBER 24 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	5	-9	-9	-9
1 - 2	3	-9	-9	-9
2 - 3	3	-9	-9	-9
3 - 4	3	-9	-9	-9
4 - 5	2	-9	-9	-9
5 - 6	2	-9	-9	-9
6 - 7	1	-9	-9	-9
7 - 8	2	-9	-9	-9
8 - 9	3	-9	-9	-9
9 - 10	3	-9	-9	-9
10 - 11	2	-9	-9	-9
11 - 12	1	-9	-9	-9
12 - 13	2	-9	-9	-9
13 - 14	2	-9	-9	-9
14 - 15	2	-9	-9	-9
15 - 16	3	2.2	0.85	3.05
16 - 17	2	2.07	0.92	2.99
17 - 18	2	2.02	0.93	2.95
18 - 19	2	1.81	0.71	2.52
19 - 20	1	1.63	0.52	2.15
20 - 21	1	1.73	0.54	2.27
21 - 22	1	1.75	0.58	2.33
22 - 23	1	1.67	0.56	2.23
23 - 24	1	1.49	0.27	1.76
AVERAGE VALUES	2.08333	1.81889	0.653333	2.47222
MAXIMUM VALUE	5	2.2	0.93	3.05

BUSCH GARDENS EXPERIMENT
OLD DOMINION UNIVERSITY
AIR POLLUTION RESEARCH GROUP

OCTOBER 25 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	1	1.37	0.15	1.52
1 - 2	2	1.34	0.19	1.53
2 - 3	1	1.34	0.15	1.49
3 - 4	1	1.33	0.19	1.52
4 - 5	0.5	1.44	0.24	1.68
5 - 6	0.5	1.53	0.24	1.77
6 - 7	0	1.5	0.19	1.69
7 - 8	0	1.42	0.21	1.63
8 - 9	0.5	1.57	0.3	1.87
9 - 10	1	1.58	0.24	1.82
10 - 11	1	1.59	0.38	1.97
11 - 12	0	1.54	0.28	1.82
12 - 13	1	1.58	0.29	1.87
13 - 14	1	1.54	0.32	1.86
14 - 15	2	1.61	0.42	2.03
15 - 16	3	1.58	0.38	1.96
16 - 17	6	1.72	0.58	2.3
17 - 18	4	1.69	0.33	2.02
18 - 19	5	1.96	0.6	2.56
19 - 20	8	2.03	0.76	2.79
20 - 21	5	1.86	0.29	2.15
21 - 22	5	2.05	0.46	2.51
22 - 23	3	2.05	0.47	2.52
23 - 24	4	2.28	1.7	3.98
AVERAGE VALUES	2.3125	1.64583	0.39	2.03583
MAXIMUM VALUE	8	2.28	1.7	3.98

BUSCH GARDENS EXPERIMENT
OLD DOMINION UNIVERSITY
AIR POLLUTION RESEARCH GROUP

OCTOBER 26 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	3	2.17	0.5	2.67
1 - 2	3	2.17	0.39	2.56
2 - 3	4	2.42	0.37	2.79
3 - 4	4	2.45	0.49	2.94
4 - 5	3	2.66	0.54	3.2
5 - 6	3	2.89	0.76	3.65
6 - 7	4	3.01	0.6	3.61
7 - 8	3	2.76	0.99	3.75
8 - 9	4	2.54	1.11	3.65
9 - 10	6	2.13	0.88	3.01
10 - 11	5	1.9	0.44	2.34
11 - 12	3	2.31	0.75	3.06
12 - 13	1	2.52	0.77	3.29
13 - 14	0	2.49	0.79	3.28
14 - 15	1	2.36	0.8	3.16
15 - 16	1	2.52	0.86	3.38
16 - 17	5	2.45	0.69	3.14
17 - 18	6	2.54	0.66	3.2
18 - 19	6	2.62	0.76	3.38
19 - 20	5	2.62	0.67	3.29
20 - 21	4	2.66	0.64	3.3
21 - 22	3	2.72	0.61	3.33
22 - 23	4	2.59	0.56	3.15
23 - 24	3	2.47	0.45	2.92
AVERAGE VALUES	3.5	2.49875	0.67	3.16875
MAXIMUM VALUE	6	3.01	1.11	3.75

BUSCH GARDENS EXPERIMENT
OLD DOMINION UNIVERSITY
AIR POLLUTION RESEARCH GROUP

OCTOBER 27 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	3	2.44	0.32	2.76
1 - 2	3	2.51	0.45	2.96
2 - 3	3	2.6	0.43	3.03
3 - 4	3	2.54	0.49	3.03
4 - 5	3	2.56	0.51	3.07
5 - 6	3	2.52	0.45	2.97
6 - 7	3	2.51	0.47	2.98
7 - 8	3	2.6	0.61	3.21
8 - 9	2	2.67	0.62	3.29
9 - 10	2	2.69	0.65	3.34
10 - 11	2	2.71	0.6	3.31
11 - 12	2	2.57	0.53	3.1
12 - 13	2	2.35	0.54	2.89
13 - 14	3	2.41	0.5	2.91
14 - 15	2	2.41	0.61	3.02
15 - 16	4	2.54	0.71	3.25
16 - 17	3	2.51	0.68	3.19
17 - 18	2	2.66	0.73	3.39
18 - 19	2	2.77	0.84	3.61
19 - 20	2	2.81	1.01	3.82
20 - 21	2	2.87	0.86	3.73
21 - 22	0	3.2	1.07	4.27
22 - 23	1	3.17	1.05	4.22
23 - 24	3	3.2	1.17	4.37
AVERAGE VALUES	2.41667	2.65917	0.6625	3.32167
MAXIMUM VALUE	4	3.2	1.17	4.37

BUSCH GARDENS EXPERIMENT
OLD DOMINION UNIVERSITY
AIR POLLUTION RESEARCH GROUP

OCTOBER 28 1975

TIME EDST	CO PPM	CH4 PPM	HC-CH4 PPM	TOTAL HC PPM
0 - 1	2	3.33	1.27	4.6
1 - 2	2	3.43	1.37	4.8
2 - 3	2	3.21	1.13	4.34
3 - 4	2	3.11	1.06	4.17
4 - 5	1	3.01	0.99	4
5 - 6	1	3.24	1	4.24
6 - 7	2	3.24	0.91	4.15
7 - 8	2	3.33	1.24	4.57
8 - 9	2	3.06	0.76	3.82
9 - 10	3	2.71	0.6	3.31
10 - 11	2	2.26	0.49	2.75
11 - 12	3	2.26	0.41	2.67
12 - 13	3	2.21	0.48	2.69
13 - 14	3	2.31	1.14	3.45
14 - 15	3	2.21	0.75	2.96
15 - 16	4	2.25	0.49	2.74
16 - 17	5	2.36	0.59	2.95
17 - 18	6	2.4	0.5	2.9
18 - 19	6	2.67	1.12	3.79
19 - 20	6	3.02	1.62	4.64
20 - 21	5	2.64	2.22	4.86
21 - 22	5	2.67	0.67	3.34
22 - 23	4	2.77	0.88	3.65
23 - 24	3	2.47	0.68	3.15
AVERAGE VALUES	3.20833	2.75708	0.932083	3.68917
MAXIMUM VALUE	6	3.43	2.22	4.86