In 1973, J.M. Knott published *Effects of Urbanization on Sedimentation and Floodflows on Colma Creek Basin, California*, in which he predicts that increasing urbanization and decreasing construction activity will result in substantial declines in sediment yields by 1980. No matter how hard a student tries, current data does not allow corroboration of Mr. Knott’s predictions. However, a comparison of mean discharge from periods of partial and full urbanization finds a significantly greater mean discharge during the period of complete urbanization. The increase in discharge is probably due to the basin’s increased impermeable surface area and its diversion of rainwater from the ground to the storm system and into Colma Creek.
Located on the San Francisco peninsula approximately ten miles south of the Golden Gate, Colma Creek is an eight mile long tributary to San Francisco Bay. Colma Creek and its basin are located in a highly urbanized landscape where presently sixty-five percent of land uses are urban. Similar to most urban areas in the United States, Colma Creek basin underwent significant urbanization during the post-World War II suburban movement.

During the 1960’s and 1970’s, the United States Geological Survey (USGS) conducted a number of studies on the impacts of urbanization on fluvial systems. Colma Creek was among the urban streams studied, and in 1973, the USGS published a report, *Effects of Urbanization on Sedimentation and Floodflows on Colma Creek Basin, California*. The report examines changes in water and sediment discharge during periods of urban expansion in the Colma Creek Basin. The report concluded that with an anticipated increase in urbanization and a decrease in construction activity over the following ten years (1971-80), sediment yields may decline substantially.

The purpose of this study is to revisit the findings of the now-30 year-old report. Given that urbanization in the Colma Creek basin is complete, sediment yields should be significantly below the yields of the USGS study period. Current streamflow data may also demonstrate other evidence of urbanization, such as shorter times to peak flows. Finally, one may see how the cities and towns have coped with the creek by surveying the surrounding land uses.

---

1 The length of Colma Creek is an approximate measure, having been arrived at with string and a 1993 USGS topographic quadrangle.
Literature Review

Urbanization and Sedimentation

Of primary interest is M. Gordon Wolman’s theory of changes in sediment production, which he put forth in his 1967 article, “A cycle of sedimentation and erosion in urban river channels.” Wolman’s theory is based upon the concept of equilibrium, or the idea that in the short term, the forces and processes which create and degrade a landform are in a state of balance. Thus, in a fluvial system, the channel slope and form will, over a period of years, adjust to the quantity of water and to the quantity and characteristics of the sediment load provided by the drainage basin. Wolman reasons that major disturbances on the drainage basin of a stream in a state of equilibrium will result in changes in channel form and behavior of that stream. One such disturbance on a watershed landscape is the process of urbanization, with its accompanying acts of deforestation, soil denudation, and hardscape accumulation. Therefore, Wolman states, urbanization “can be expected to alter markedly the equilibrium forms and may result in the eventual establishment of new conditions of equilibrium.”

Key to Wolman’s theory is his focus on the “cycle of urbanization” (see Figure 2). Wolman has identified three stages in a process of urbanization. The first stage is an initial stable or equilibrium condition in which the landscape may be primarily agricultural or forested. The second stage is a period of construction during which bare soil is exposed to erosion. The third and final stage is a built urban environment consisting of hardscape and impervious surfaces such as rooftops, paved streets, gutters, and sewers. Given these three successive stages, Wolman theorizes that one will observe corresponding changes in a stream’s sediment yield. During a period of construction, with its increase in exposure of bare soil to erosive elements, sediment

---

yield will rise to multiple times the levels of those of the initial equilibrium stage. Following construction, if the entire drainage basin has been developed, sediment yields will decline to levels at or below those of the initial stage.

In the case of Colma Creek, one may expect to see at least two changes in characteristics due to urbanization. First, there may be changes in the creek’s equilibrium form. Second, current sediment yields may be at or below the levels recorded during periods of urban expansion.

*Impacts of Urbanization*

By increasing the impermeable surface area of a stream basin, urbanization impacts stream channels, flow, and flood hydrographs. Urbanization introduces paving, rooftops, and gutters to a landscape, all of which are impermeable and force rainwater to flow into a system of stormdrains and culverts which has been designed to transport rainwater away from an urban area. With more hardscape and less exposed soil, there is a consequent decrease in an urban stream’s sediment load. With less sediment to carry, the stream can direct its energies into a faster flow. In addition, with less exposed soil into which rainwater can filter, the total runoff increases.
By affecting flow, infiltration, and runoff, urbanization impacts also a flood’s behavior as reflected in a flood hydrograph. A hydrograph is a graphic representation of stream discharge over time. An urban flood hydrograph is characterized by a decreased lag time between rainfall peaks and flood peaks, an increase in the magnitude of flood peaks, and an increase in the total runoff volume. The decreased lag time is a result of greater hydraulic efficiency; rainwater flows over hardscape quicker than it filters through soil or saturates land before resulting in overland flow. The magnitude of flood peaks increase, and total discharge increases as well, because urbanization forces rainwater into a transport system, such as sewerage and stream, rather than allowing it to filter into the soil (Figure 3).

**Stream Channelization**

Andrew Brookes has written extensively on the subject of stream channelization. He is one of the first to have recognized stream channelization as an object of geomorphologic, and not just engineering, study. Brookes defines channelization as "the modification of river channels for the purposes of flood control, land drainage, navigation and the prevention of erosion." One may divide Brookes’s study of channelization into three groups: methods of river channelization,
the physical consequences of river channelization, and alternative approaches to river channelization. Brookes collected his studies in *Channelized Rivers: Perspectives for Environmental Management*. Although published in 1988, the book continues to be quite relevant, as the information put forth on the methods and impacts of channelization have, generally speaking, remained true. In addition, *Channelized Rivers* contains an almost encyclopedic bibliography.

Of interest to the study of Colma Creek are the impacts of channelization. As previously noted, Colma Creek has been lined and straightened along almost its entire course. While such channelization is bad for the stream, it is fortuitous for the student, who needs not note the types of impacts typically found upstream and downstream from a channelized section. Generally speaking, the idea behind channelization is to control a stream and its environmental impacts (flooding, bank erosion, pooling and riffling) by capitalizing upon a stream’s ability to move water. One goal is to move and to dispose of water as quickly and efficiently as possible, before the water has a chance to collect and to overburden a stream’s capacity. For this reason, one lines a channel, with concrete in the case of Colma Creek, to reduce bed roughness and therefore to increase flow velocity by minimizing friction. Lining a channel also has an effect of eradicating riparian vegetation, which can add friction and decrease flow velocity. Another means of facilitating the flow of water is to straighten a channel. Removal of meander bends shortens the length of a stream and steepens its grade. Removal of meander bends with a concrete liner also fulfills a goal to stabilize banks. Many consider bank erosion a problem because of a loss of personal property to plops in a stream.

---

While channelization may provide peace of mind to denizens of a drainage basin, it brings with it many negative effects as well. The most apparent impact of channelization is the reduction in the complexity of the stream system. The straightening of the channel eliminates meander bends, pools, riffles, and other non-uniformities in channel geometry which may provide habitat to riparian wildlife. Removal of riparian vegetation will also affect riparian wildlife, as well as increase water temperatures and thereby decrease levels of dissolved oxygen. As a higher flow velocity increases a stream’s competence, one finds increased sedimentation and flooding downstream from a channelized stream.

An interesting question is how a stream behaves within a lined channel. Does a stream within such rigid structural controls exhibit stream-like behavior, or does it merely resemble a flow of water as one would find from a spigot? Brookes notes that “adjustments occurring specifically within concrete-lined channels are less well documented, although there is often a requirement to remove sediment which has accumulated above the artificial substrate.” However, Jeffrey Mount, writing seven years later, observes that “flow behavior and sediment transport characteristics of a modified river will usually attempt to restore a meandering or

---

braided pattern and reestablish the original gradient.”

**General Description**

Colma Creek is an eight mile long tributary to San Francisco Bay. Colma Creek Basin comprises a 16.3 square mile area on the east side of the San Francisco peninsula. The basin is bounded on the northeast by San Bruno Mountain and on the west by the ridge traced by Skyline Boulevard. Elevations range from sea level at the mouth to more than 1,300 feet above mean sea level on San Bruno Mountain.

Colma Creek flows from San Bruno Mountain southwest through Daly City to the Town of Colma, where it meets up with its west fork which has its origins near Skyline Boulevard. Through Colma, the creek flows along El Camino Real to Mission Street, where it heads east through the City of South San Francisco. The creek continues east, through Orange Park and under the Bayshore Freeway to San Francisco Bay, where it reaches its outlet just north of the San Francisco International Airport.

**Geology**

The northeast portion of Colma Creek basin along which San Bruno Mountain lies is underlain by relatively resistant sandstone and shale, commonly known as greywacke. The highlands along the western boundary are made of much younger and less resistant rock, marine

---


sediment of Tertiary and Quaternary age containing friable and firmly cemented sand, silt, clay, and minor quantities of gravel. The area within the valley is mostly of Quaternary age and is similar to material underlying the western highlands.

Vegetation

Vegetation in the Colma Creek basin consists primarily of lawns, parks, and native grasses in the urban foothill areas. One finds chaparral in the higher elevations and riparian habitats on San Bruno Mountain.

Climate

Eighty-five percent of the annual rainfall occurs from November to March. Summers are warm and dry with little precipitation while winters are mild and humid.

Land Use

In the Colma Creek basin, there are four general types of land use: open-space, urban and industrial, agricultural or undeveloped, and under construction. I have adopted the definitions used in the USGS report. Open-space areas are those areas where soils are protected by native or re-established vegetation, parks, and cemeteries. Urban and industrial areas include residential, including lawns and gardens, commercial, and industrial uses. Agricultural or undeveloped areas are those areas where soils have been under cultivation for many years. This category includes those areas of older exposed soil where vegetation has not been reestablished. Areas under construction include freshly excavated areas as well as areas that have been exposed for a number of years.
Table 1: Colma Creek Basin Land Use by percentage of total

<table>
<thead>
<tr>
<th>Year</th>
<th>Urban and Industrial</th>
<th>Open Space</th>
<th>Agricultural or Undeveloped</th>
<th>Under Construction</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1946</td>
<td>15</td>
<td>15</td>
<td>70</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>1956</td>
<td>34</td>
<td>51</td>
<td>12</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>1970</td>
<td>54</td>
<td>37</td>
<td>3</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>1980 (projected)*</td>
<td>62</td>
<td>35</td>
<td>3</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>1998</td>
<td>63</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>---</td>
</tr>
</tbody>
</table>

Sources: Knott, 1973; City of Daly City, 2001.

The Colma Creek Basin has witnessed dramatic land use changes over the past fifty years (see Table 1). In 1946, the area was overwhelmingly agricultural or undeveloped. More than two-thirds of the land area was agricultural or undeveloped, while less than one third was devoted either to urban and industrial uses or to open space uses, such as cemeteries and parks. Within ten years, the majority of the land use was open space (51 percent) and urban and industrial uses more than doubled. Meanwhile, agricultural and undeveloped land declined from two-thirds to one-eighth. Three percent of the land was under construction, a reflection of the post-World War II development boom. By 1970, urban and industrial lands increased to more than one-half while open space declined to a little more than one-third, an inverse of the relationship in 1956. Agricultural and undeveloped land declined even further to a mere 3 percent, a sliver of the 70 percent it had been just 24 years earlier. Finally, in 1998, almost two-thirds of the land in the fully urbanized creek basin was devoted to urban and industrial uses. It is likely that open space continued to be the second-most prevalent land use, owing to the numerous cemeteries in Colma and to the parklands on San Bruno Mountain.

7 Knott, 33.
Channelization

Colma Creek has been channelized almost throughout its entire reach. The upper reaches in San Bruno Mountain State and County Park appear not to be channelized. However, the stream is culverted immediately at the park’s boundary and remains either culverted or channelized until its outlet at San Francisco Bay. For those readers with a morbid curiosity, most of the observed channels are concrete-lined and rectangular. Through the industrial stretch east of the Bayshore Freeway, the channel widens and there is a significant amount of sedimentary deposition.
Colma Creek has been channelized almost throughout its course. The only portion which is not apparently channelized is in San Bruno Mountain County Park.

Figure 7a-c. Colma Creek has been channelized almost throughout its course. The only portion which is not apparently channelized is in San Bruno Mountain County Park.
Figure 8. Near South Airport Boulevard in South San Francisco. This area suffers from frequent winter flooding.

Figure 9. Colma Creek’s outlet at San Francisco Bay.
USGS Report: J.M. Knott’s Analysis of Colma Creek

To assess the impacts of urbanization on Colma Creek, J.M. Knott conducted three sets of analysis. He looked at changes in storm runoff characteristics between 1964 and 1971. He also examined trends in peak flow as well as sediment discharge.

The original intention of this report is to follow up on Knott’s study by replicating his analysis, if possible. It is seemingly fortunate that high quality data for the Colma Creek Basin is available from the USGS and the National Oceanic and Atmospheric Administration (NOAA). The available data are:

- Daily discharge, Colma Creek, WY 1964 – 1996
- Peak flow, Colma Creek, 1963 – 1996
- Suspended sediment load, Colma Creek, 1965 – 1975
- Size distribution of suspended material, Colma Creek, 1965 – 1982
- Hourly precipitation, San Francisco International Airport, 1931 – present

Changes in storm runoff characteristics between 1964 and 1971

To analyze changes in storm runoff characteristics between 1964 and 1971, Knott compares total rainfall to total runoff for select storms with more than 0.4 inch of rainfall. A scatterplot of his data points suggests that a larger percentage of storm rainfall was discharged as runoff during the latter part of the period. However, whether the increased runoff is due to the addition of impervious surface area is unclear, as Knott observes that the variance was large and the dataset was small.\(^8\)

If the increased runoff is indeed due to the addition of impervious surface area, then one may see progressively increasing runoff as the Colma Creek basin became more urbanized. Unfortunately, it is not possible to duplicate Knott’s analysis with current data. While hourly rainfall data from the San Francisco Airport continues to be available, discharge data is available...
in daily increments only. Isolation of individual storm discharges is difficult when given only daily discharge amounts.

*Trends in peak flow*

Using the same storms as used in the rainfall-to-runoff analysis, Knott compared the relation of peak water discharge to storm rainfall during the two hours prior to the peak flow. He found little change in the relation between peak flow and rainfall. The variability between peak flow and rainfall may have been due to what he cited as “unusual physical characteristics of the Colma Creek basin,” such as the establishment of debris basins, which retard storm runoff and reduce peak flows.\(^9\) He also supposed that flooding upstream from the gaging station may dampen peak flows, since water flows through urban areas at a slower rate than it does through stream channels.

While peak flow data is available for Colma Creek, the data does not include the times at which they occur. Therefore, it is difficult to gage the relation of peak water discharge to storm rainfall, and it is impossible to duplicate Knott’s analysis.

*Relationship between sediment and water discharge*

To study the relationship between sediment and water discharge, Knott compared sediment transport curves, expressed by the equation:

\[
Q_s = K C_s Q_w ,
\]

where \(Q_s\) is the sediment discharge, in tons per day, \(K\) is a constant (equivalent to 0.0027 for sediment having a specific gravity of 2.65, \(C_s\) is the concentration of suspended sediment, in milligrams per liter, and \(Q_w\) is the water discharge, in cubic feet per second.

---

\(^8\) Knott, 19.
\(^9\) Knott, 20.
Figure 10. Knott’s graphs comparing rainfall to runoff for a selected storm.

Figure 11. Scatterplots of peak discharge to storm rainfall for selected storms between 1964 and 1971.
Knott found that while the sediment-transport curves for 1966-1969 showed little change in sediment discharge during streamflows larger than 100 cfs, the curve for 1970 showed a large decrease in the rate of sediment discharge for all flows. He attributed this decrease primarily to a large decrease in construction between 1969 and 1970.

If fluctuations in sediment-transport curves are indeed due to changes in construction activity, then sediment-transport curves for subsequent years to the present should reflect the decrease in construction activity from a high of six percent of total land use in 1970 to a negligible amount found today. One expects the sediment-transport curves to reach a low during the 1980s, when urbanization of the basin was probably completed, and to remain stable through the 1990s to the present. Unfortunately, suspended sediment load data is only available for ten years, from 1965 through 1975. The number of years available is not significantly more than was available in the original study (1966-1970). Also, the data does not span the post-construction high urban land use years, which prevents us from conducting the desired analysis.

**Do-What-You-Can-With-Statistics Analysis**

While the data are incompatible to J.M. Knott’s analysis, many are nevertheless valuable in their own right. Granted, the suspended sediment load data are temporally insufficient and the size distribution of suspended material data are a mystery. Thus, rather than look at sediment load, this study will focus instead on the precipitation and discharge data. As noted earlier, the Colma Creek basin underwent urbanization from 1964 to 1994, with urban and industrial land use increasing from less than one-half in 1964 to almost two-thirds in 1994. An increase in urban and industrial land means an increase in hardscape and an overall decrease in permeable ground into which rainwater may filter. Thus, with increased urbanization, the stormwater system of
paving, drains, and gutters will divert a higher percentage of rainwater into Colma Creek and increase its discharge.

Changes in Runoff Ratio

According to Sala and Inbar, “the cumulative curve of annual precipitation against cumulative annual direct runoff shows periods of increased runoff which correspond to the time of accelerated urbanization.”\textsuperscript{10} It is expected that the cumulative curve of precipitation would increase steadily, thereby indicating no change in rainfall from year to year. Where the cumulative curve of direct runoff breaks “(shows) the effect of pulses of development” through increases in runoff.

While the Colma Creek basin certainly experienced accelerated urbanization during the study period, “pulses of development” are not clearly shown in a plot of cumulative curves (Figure 13). The cumulative annual discharge line shows two points of increasing discharge, at 1974 and 1983. However, these increases are paralleled by increases, of a lower magnitude, in the cumulative annual precipitation. It is visually unclear whether the increases in discharge are due to an increase in urbanization, or to an increase in precipitation. If the increase is indeed due to urbanization, then one should find a corresponding increase in the creek’s discharge. This requires a closer examination of mean monthly discharge figures, normalized by precipitation (Figure 14). The graph shows an overall trend toward increasing rates of discharge per unit of precipitation. Mean monthly discharge per unit of precipitation increases until its peak at 1974, after which it drops off sharply due to drought in the region. After 1977, mean monthly discharge per unit of precipitation begins to increase again, reaching a peak in 1989.

Figure 12. Cumulative annual precipitation and cumulative annual discharge, Colma Creek, 1964 - 1994.

Figure 13. Mean monthly discharge to mean monthly precipitation, Colma Creek, 1964 – 1994.
The graph also shows differences between the first ten years of the study period and the latter half of the period. From 1964 to 1974, the line rises fairly steadily with moderate peaks and valleys. In contrast, the increase from 1977 to 1989 is much more erratic with greater variability. Perhaps the instability of the later years is due to an increase in impermeable surface; with less surface area through which precipitation can permeate and recharge the groundwater, the creek’s discharge may be more prone to the vagaries of precipitation.

*Independent Samples T-Test: Comparison of Sample Means*

To test whether the mean monthly discharge of the later years is significantly greater than the mean monthly discharge of the earlier years, I compared the means of two eleven-year samples, 1964 to 1974 and 1984 to 1994. 1964 to 1974 concurs with the study period of the Knott report. It is also a period of increasing urbanization; as mentioned earlier, about 6 percent of the creek basin was under construction. On the other hand, 1984 to 1994 is a period of complete urbanization, with little significant construction activity.

A comparison of the cumulative precipitation and discharge curves for the two periods show a visual difference between the two (figure 14). The later period appears to have a greater ratio of discharge to precipitation than does the earlier period.

To test whether the apparent difference between the two periods is significant, I conducted a T-test on the sample means. The mean discharge from 1964 to 1974 is 135.07 cfs per inch of precipitation with a standard deviation of 35.23. The mean discharge from 1984 to 1994 is 171.58 cfs per inch of precipitation with a standard deviation of 26.32. The calculated test statistic of 2.62 is greater than the tabulated test statistic of 2.09 (where $\alpha/2 = 0.025$). Therefore, the mean monthly discharge from 1964 to 1974 is significantly different from the mean monthly discharge from 1984 to 1994. The increase in discharge is probably due to the
basin’s increased impermeable surface area and its diversion of rainwater from the ground to the storm system and into Colma Creek.

**Conclusion**

The Colma Creek basin has undergone extensive urbanization in the latter half of the 20th century, growing from 70 percent agricultural use in 1946 to 63 percent urban and industrial use in 1998. A comparison of discharge rates between 1964 to 1974 and 1984 to 1994 finds a significant increase in the creek’s discharge during the latter more urbanized period. Whether this study warrants further investigation is questionable, as this study is largely an exercise for a student with basic skills who wanted to play with a real stream and its real data. However, Colma Creek itself is worthy of further study, perhaps because it is an ordinary urban creek and subject to ordinary treatments of flood control, channelization, and land use policy.
Literature Cited


Appendix A

Table 2. Precipitation and Discharge, Colma Creek, 1964 - 1994

<table>
<thead>
<tr>
<th>water year</th>
<th>annual precipitation (ins)</th>
<th>mean monthly precipitation (ins)</th>
<th>cumulative annual precipitation (ins)</th>
<th>annual discharge (cfs)</th>
<th>mean monthly discharge (cfs)</th>
<th>cumulative annual discharge (cfs)</th>
<th>cumulative annual discharge (100 cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>12.61</td>
<td>1.05</td>
<td>12.61</td>
<td>853</td>
<td>71.08</td>
<td>853</td>
<td>9</td>
</tr>
<tr>
<td>1965</td>
<td>20.80</td>
<td>1.73</td>
<td>33.41</td>
<td>2044</td>
<td>170.31</td>
<td>2897</td>
<td>29</td>
</tr>
<tr>
<td>1966</td>
<td>17.65</td>
<td>1.47</td>
<td>51.06</td>
<td>1696</td>
<td>141.35</td>
<td>4593</td>
<td>46</td>
</tr>
<tr>
<td>1967</td>
<td>30.75</td>
<td>2.56</td>
<td>81.81</td>
<td>4722</td>
<td>393.51</td>
<td>9315</td>
<td>93</td>
</tr>
<tr>
<td>1968</td>
<td>15.88</td>
<td>1.32</td>
<td>97.69</td>
<td>1918</td>
<td>159.79</td>
<td>11233</td>
<td>112</td>
</tr>
<tr>
<td>1969</td>
<td>28.24</td>
<td>2.35</td>
<td>125.93</td>
<td>3889</td>
<td>324.11</td>
<td>15122</td>
<td>151</td>
</tr>
<tr>
<td>1970</td>
<td>19.56</td>
<td>1.63</td>
<td>145.49</td>
<td>2898</td>
<td>241.50</td>
<td>18020</td>
<td>180</td>
</tr>
<tr>
<td>1971</td>
<td>18.71</td>
<td>1.56</td>
<td>164.20</td>
<td>2762</td>
<td>230.18</td>
<td>20782</td>
<td>208</td>
</tr>
<tr>
<td>1972</td>
<td>8.64</td>
<td>0.72</td>
<td>172.84</td>
<td>1519</td>
<td>126.58</td>
<td>22301</td>
<td>223</td>
</tr>
<tr>
<td>1973</td>
<td>31.08</td>
<td>2.59</td>
<td>203.92</td>
<td>5068</td>
<td>422.37</td>
<td>27369</td>
<td>274</td>
</tr>
<tr>
<td>1974</td>
<td>24.90</td>
<td>2.08</td>
<td>228.82</td>
<td>4399</td>
<td>366.58</td>
<td>31768</td>
<td>318</td>
</tr>
<tr>
<td>1975</td>
<td>18.30</td>
<td>1.53</td>
<td>247.12</td>
<td>1901</td>
<td>158.42</td>
<td>33669</td>
<td>337</td>
</tr>
<tr>
<td>1976</td>
<td>8.35</td>
<td>0.70</td>
<td>255.47</td>
<td>928</td>
<td>77.31</td>
<td>34597</td>
<td>346</td>
</tr>
<tr>
<td>1977</td>
<td>10.91</td>
<td>0.91</td>
<td>266.38</td>
<td>1014</td>
<td>84.47</td>
<td>35611</td>
<td>356</td>
</tr>
<tr>
<td>1978</td>
<td>29.54</td>
<td>2.46</td>
<td>295.92</td>
<td>3199</td>
<td>266.59</td>
<td>38810</td>
<td>388</td>
</tr>
<tr>
<td>1979</td>
<td>18.44</td>
<td>1.54</td>
<td>314.36</td>
<td>2345</td>
<td>195.40</td>
<td>41154</td>
<td>412</td>
</tr>
<tr>
<td>1980</td>
<td>24.83</td>
<td>2.07</td>
<td>339.19</td>
<td>3431</td>
<td>285.94</td>
<td>44586</td>
<td>446</td>
</tr>
<tr>
<td>1981</td>
<td>14.38</td>
<td>1.20</td>
<td>353.57</td>
<td>1700</td>
<td>141.69</td>
<td>46286</td>
<td>463</td>
</tr>
<tr>
<td>1982</td>
<td>34.68</td>
<td>2.89</td>
<td>388.25</td>
<td>4928</td>
<td>410.64</td>
<td>51214</td>
<td>512</td>
</tr>
<tr>
<td>1983</td>
<td>37.26</td>
<td>3.11</td>
<td>425.51</td>
<td>6470</td>
<td>539.15</td>
<td>57683</td>
<td>577</td>
</tr>
<tr>
<td>1984</td>
<td>16.52</td>
<td>1.38</td>
<td>442.03</td>
<td>2760</td>
<td>230.03</td>
<td>60444</td>
<td>604</td>
</tr>
<tr>
<td>1985</td>
<td>17.05</td>
<td>1.42</td>
<td>459.08</td>
<td>2415</td>
<td>201.25</td>
<td>62859</td>
<td>629</td>
</tr>
<tr>
<td>1986</td>
<td>24.48</td>
<td>2.04</td>
<td>483.56</td>
<td>3322</td>
<td>276.80</td>
<td>66180</td>
<td>662</td>
</tr>
<tr>
<td>1987</td>
<td>10.26</td>
<td>0.86</td>
<td>493.82</td>
<td>1762</td>
<td>146.81</td>
<td>67942</td>
<td>679</td>
</tr>
<tr>
<td>1988</td>
<td>14.37</td>
<td>1.20</td>
<td>508.19</td>
<td>2844</td>
<td>237.02</td>
<td>70786</td>
<td>708</td>
</tr>
<tr>
<td>1989</td>
<td>14.98</td>
<td>1.25</td>
<td>523.17</td>
<td>3480</td>
<td>290.02</td>
<td>74266</td>
<td>743</td>
</tr>
<tr>
<td>1990</td>
<td>10.84</td>
<td>0.90</td>
<td>534.01</td>
<td>1895</td>
<td>157.92</td>
<td>76161</td>
<td>762</td>
</tr>
<tr>
<td>1991</td>
<td>13.57</td>
<td>1.13</td>
<td>547.58</td>
<td>2353</td>
<td>196.07</td>
<td>78514</td>
<td>785</td>
</tr>
<tr>
<td>1992</td>
<td>18.04</td>
<td>1.50</td>
<td>565.62</td>
<td>3191</td>
<td>265.88</td>
<td>81705</td>
<td>817</td>
</tr>
<tr>
<td>1993</td>
<td>26.71</td>
<td>2.23</td>
<td>592.33</td>
<td>4220</td>
<td>351.63</td>
<td>85924</td>
<td>859</td>
</tr>
<tr>
<td>1994</td>
<td>14.88</td>
<td>1.24</td>
<td>607.21</td>
<td>2368</td>
<td>197.32</td>
<td>88292</td>
<td>883</td>
</tr>
</tbody>
</table>