APPENDIX J

STATISTICAL ANALYSIS FOR IN-BAY GOAL MANAGEMENT

APPENDIX J

BACKGROUND

As part of the annual review of in-Bay disposal volumes, the LTMS agencies will use statistical techniques to assist in evaluation of the data. One of the techniques chosen to assist in managing the goal of low in-Bay dredged material disposal is derived from a tool known as control charts. The ASTM Manual STP-15 or ANSI Z1.1 and Z1.2 provide more explanation for those interested in more detail than is presented here. There are also many texts in the Quality Assurance discipline that describe this technique.

In 1944, W.E. Deming[1] stated:

> There is no such thing as constancy in real life. There is, however, such a thing as a constant-cause system. The results produced by a constant-cause system vary, and in fact may vary over a wide band or a narrow band. They vary, but they exhibit an important feature called stability. Why apply the terms constant and stability to a cause system that produces results that vary? Because the same percentage of these varying results continue to fall between any give pair of limits hour after hour, day after day, so long as the constant-cause system continues to operate. It is the distribution of results that is constant or stable. When a manufacturing process behaves like a constant-cause system, producing inspection results that exhibit stability, it is said to be in statistical control. The control chart will tell you whether your process is in statistical control.

In Section 8.3.2 of *A Guide to the Project Management Body of Knowledge*[2], the Project Management Institute explains:

> "Control charts are a graphic display of results, over time, of a process. They are used to determine if the process in "in control" (e.g., are differences in the results created by random variations or are unusual events occurring whose causes must be identified and corrected?). When a process is in control, the process should not be adjusted. The process may be *changed* in order to provide improvements but it should not be adjusted when it is in control. Control charts may be used to monitor any type of output variable. Although used most frequently to track repetitive activities such as manufactured lots, control charts can also be used to monitor cost and schedule variances, volume and frequency of scope changes, errors in project documents, or other management results to help determine if the "project management process" is in control.

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1 W.E. Deming, Some Principles of the Shewhart methods of Quality Control, Mechanical Engineering, vol. 66, pp. 173-177, March 1944.

2 Project Management Institute, *A Guide to the Project Management Body of Knowledge*, 1996

ADAPTATION OF TECHNIQUE

Most control charts are designed to control excursions both above and below control chart parameters. As we only intend to control excursions above an upper limit (i.e., an excess of in-Bay dredged material disposal targets), we must modify the control chart methodology to account for this one-sided control technique.

The usual parameters used in control charts are functions of the estimated standard deviation (s) and the average. These parameters are the 1s, 2s, and 3s values, 1s being the range of values within 1 standard deviation of the average, with 2s and 3s being the ranges within 2 or 3 standard deviations of the mean, respectively. In this case, the estimated standard deviation and average are calculated from the yearly in-Bay disposal volumes for the years 1991 through 1999. Because we are concerned only with abnormally high disposal volumes and not with abnormally low ones, the 1s, 2s, and 3s values must be adjusted to be appropriate for one-tailed statistical tests, to 0.475s, 1.645s, and 2.780s, respectively.

CONTROL CHART RULES

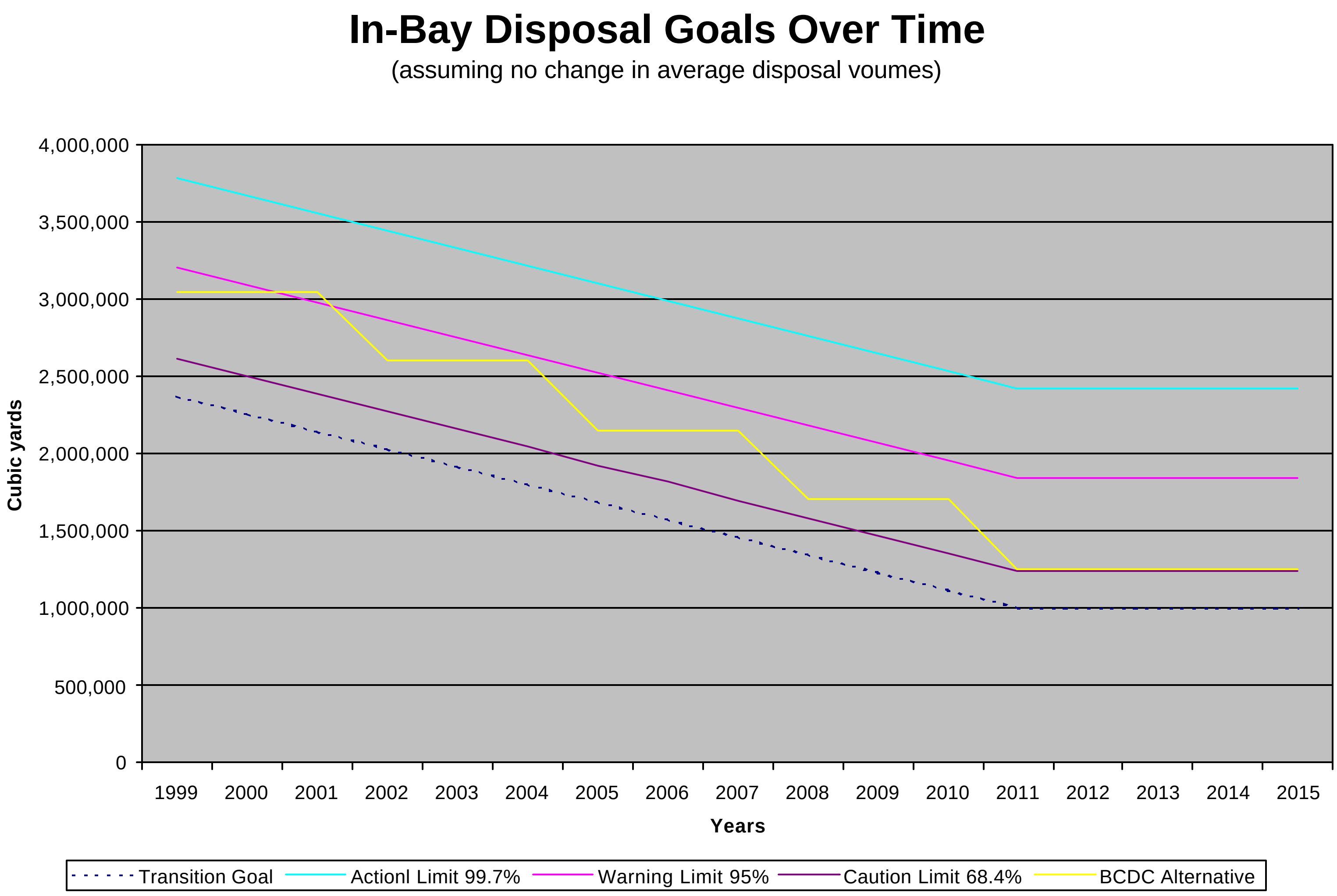
In classical control charts, the 2s and 3s values (or, in our case, the 1.645s and 2.780s values) are called the warning and action limits, respectively. Because control chart guidelines also use the 1s value (or, in our case, the 0.475s value), we have chosen to call this value the caution guidelines and renamed (for our use) the warning and action limits to warning and action guidelines. The following framework describes how the caution, warning, and action guidelines will be used in determining when to initiate investigations of high disposal volumes and possibly recommend management actions, such as initiating Phase II, to control the amount of dredged material disposed of in the Bay.

Investigation and, possibly, management action will be initiated if any of the following situations occur:

- In any year, the in-Bay disposal volume exceeds the Action guideline.
- In two of three consecutive years, the in-Bay disposal volume has exceeded the Warning guideline.
- In four of five consecutive years, in-Bay disposal volume has exceed the Caution guideline.
- Eight consecutive years of in-Bay disposal volumes are above the goal (transition or long-term).
- The in-Bay disposal volume increases six years in a row.

Figure J-1 shows the goal and the three guidelines (Caution, Warning, and Action).

Figure J-1


In-Bay Disposal Goals Over Time
(assuming no change in average disposal voumes)
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Cubic yards
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Years
Transition Goal
Actionl Limit 99.7%
Warning Limit 95%
Caution Limit 68.4%
BCDC Alternative