Greenwood Park Low Flow Analysis

Pro-bono report for Sarah Hardgrave (City of PG), by Dr Fred Watson (CSUMB). 7-Mar-2013

Background

- The City is considering installation of a stormwater treatment wetland at Greenwood Park.
- There is concern that summer flows may be too low to keep the wetland wet.
- I have applicable expertise and data, derived from a small CSUMB consultancy to the City in Spring 2012
    - This consultancy was for measurement of winter storm flows, but it yielded some information that can be extended toward estimation of summer dry-season flows

Question

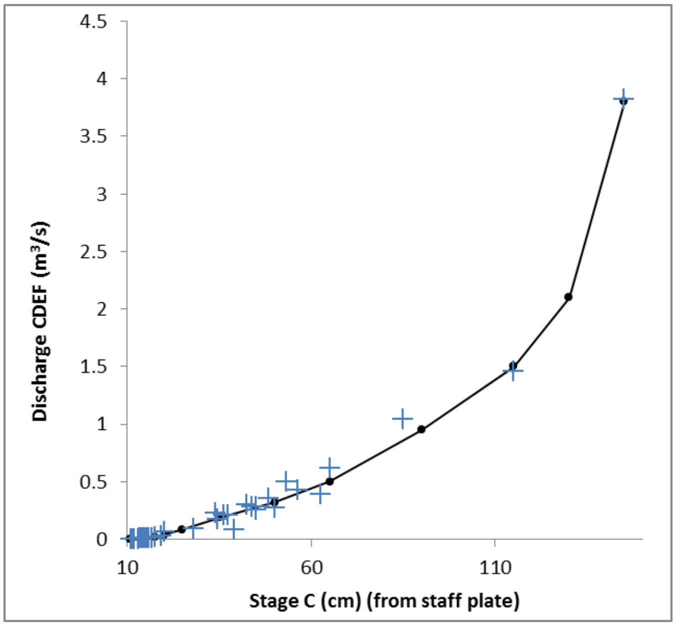
- What is the lowest monthly flow through Greenwood Park that could be reasonably expected, and will this be enough to keep a wetland wet?

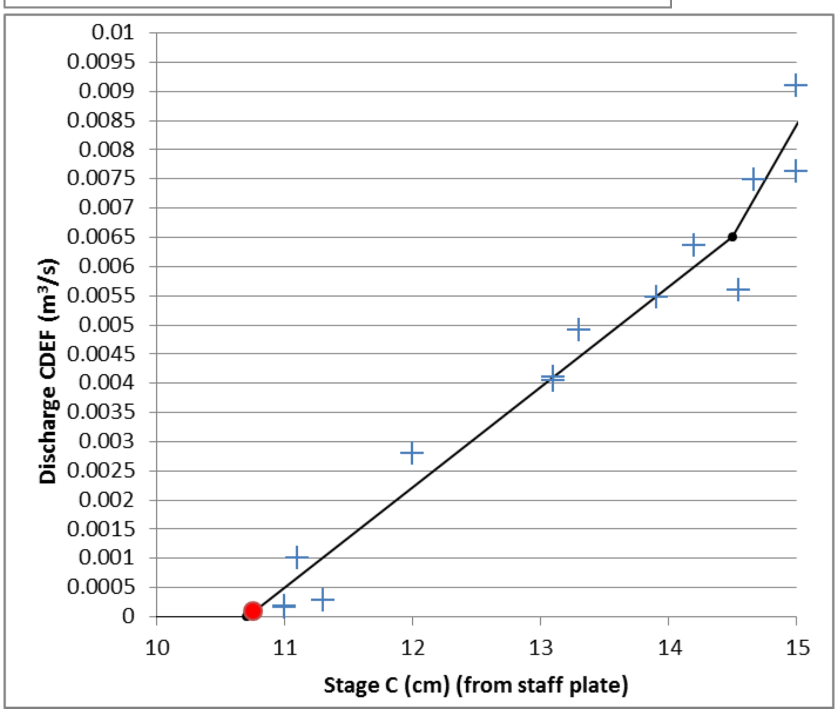
Data sources

- The longest-term data source is pump records since 2007 for the dry weather diversion. Two pumps collect water that would otherwise go to the ocean outfall, and pump it to the Marina treatment plant during the dry season. City engineers estimate that 90% of the pumped water is from GWP, and 10% is from other sources (small neighboring storm sewers etc.). The pump data were supplied in an Excel file as approximately monthly volumes pumped by each pump, but were poorly formatted with weak control on data clarity. Some interpretation was required; this was fallible; I made no effort to follow up.
- Another data source is the legacy from the Spring 2012 CSUMB storm flow monitoring project. This includes:
    - A staff plate ("Staff C") installed at the outlet of GWP
    - A rating curve developed for that staff plate, allowing estimation of flow rates (gpm) from stage height (cm), based on direct flow measurements taken in early 2012. At the lowest flows, the direct flow measurements were made by placing a bucket under the stone weir at GWP, and timing how long it took to fill. Provided all the flow went into the bucket and was not leaking around the side of the weir, this is an accurate flow estimation technique.
    - A pressure transducer record ("Stage D") just upstream of the staff plate, including stream depth measurements every 2minutes through 5-Sep-2012
    - A single manual reading of Staff C on 5-Sep-2012
- One could also use watershed modeling as a data source, but this was not done here.

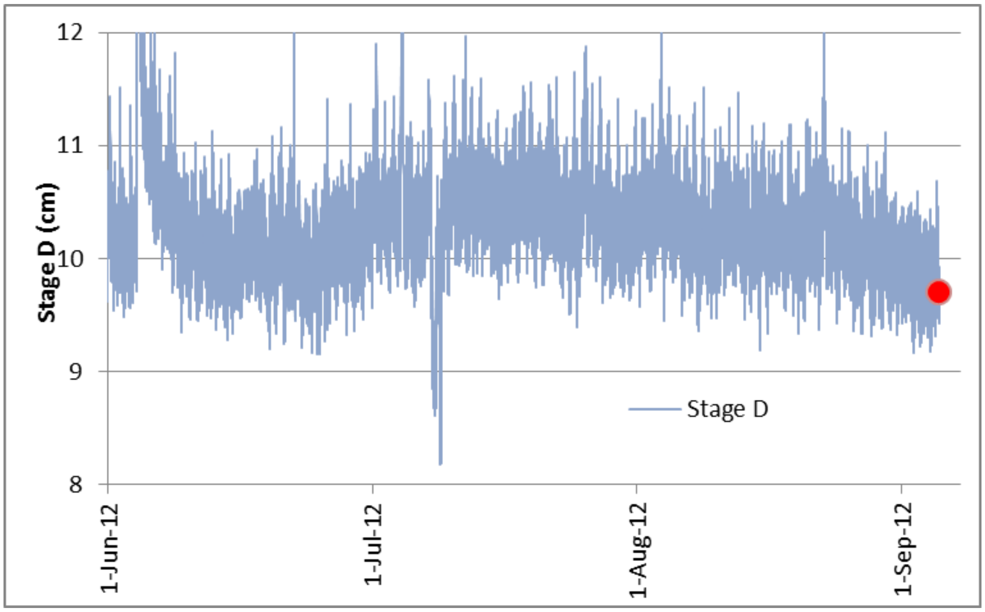
Low-flow estimation based on stream flow and stage gaging data

- Staff C on 5-Sep-2012 read 10.75 cm. The existence of flow was not recorded.
- The rating curve for Staff C is shown below, in both full and zoomed versions.
- Given the scatter about the manually-fitted line, and assuming the rating had not changed between early 2012 and Sep 2012, the actual flow on 5-Sep-2012 could plausibly have been 0.0000 and 0.0008 m3/s (0.00 and 10.17 gpm).
- The most probable flow was about 0.0001 m3/s (1.27 gpm).
  The red dot indicates this flow





- The pressure transducer record (Stage D) indicates that 5-Sep-2012 represented low flow conditions compared to the previous months in 2012:

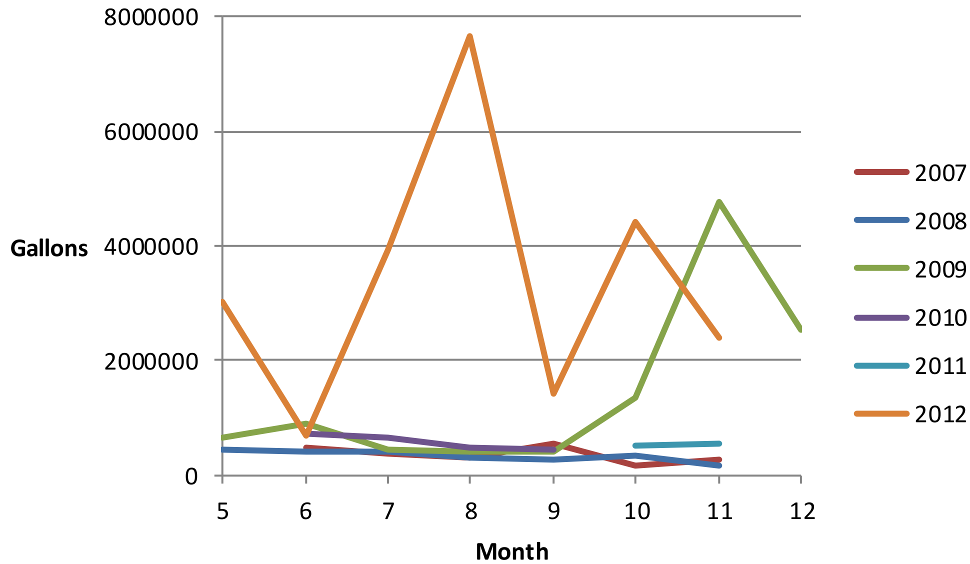


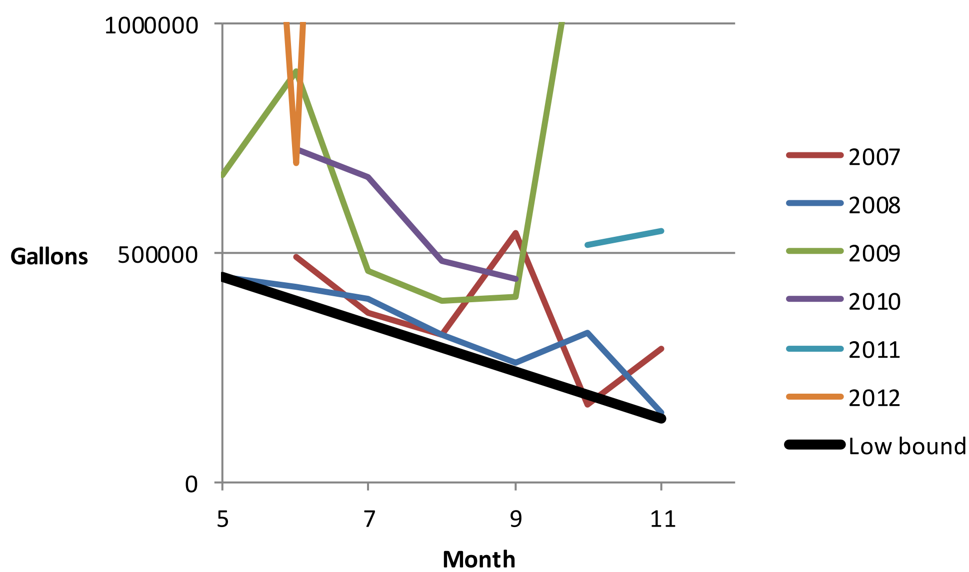
- During most of August 2012, Stage D was between 0.0 and 0.9 cm higher than it was on 5-Sep-2013 (typically around 0.5 cm higher)
- Data from Spring 2012 (not shown here) suggest that at low flows, Stage D varies four-times as much as Staff C, i.e. that a 0.4 cm variation at Stage D would be reflected as just a 0.1 cm variation at Staff C. This is because Stage D is in a narrow channel, and Staff C is near a broad pipe.
- Using this 4:1 relationship, the plausible range of Staff C during August 2012 was roughly 10.75 to 10.975 cm, typically around 10.875 cm.
- This corresponds to flow rates between 0.0002 m3/s and 0.0010 m3/s, typically around 0.0005 m3/s (2.54 to 12.71 gpm, typically around 6.35 gpm).

Low flow estimation based on pump data

- The dominant source of dry-weather flows at GWP is unknown, but plausibly includes:
    - Baseflow from groundwater, ultimately originating from the previous winter's rain
    - Sump-pumping of groundwater
    - Direct runoff from lawn irrigation overflow etc.
    - Leakage from the Cal-am distribution system
- Groundwater-based sources would be expected to gradually decline during the summer; and other sources would vary in less predictable ways.
- The pump data show a steady decline during the dry season during several years (2007, 2008, early 2009, 2010) (See graphs below).
- The pump data also show some inexplicably high pumping volumes in 2012 and late 2009

- The pattern of the 2012 data does not agree at all with the pressure transducer record from Stage D, so the 2012 pump data were assumed to be either erroneous, or reflective of substantial non-GWP inflows to the pump station.
- Because a direct comparison between stream flow gaging and pump flow data for 2012 was not possible due to pump data problems, an estimate of typical late-summer pump flow was made from a low-bound draw underneath all years of pump flow data (the thick black line below)





- The lowest flow on the low-bound line is 140,000 gallons per month, or 3.19 gallons per minute (gpm)

Agreement between two types of dry-weather flow estimate

- The estimate based on stream gaging for the lowest August 2012 flows was 2.54 gpm (see above).
- The estimate based on pumping data for the lowest monthly-average flow in the past 6 years was 3.19 gpm (see above)
- These values are not directly comparable, because they are estimates of different things; but they are generally comparable in the sense that they give a consistent indication of the order of magnitude of late-summer low flows at GWP.

How much flow is enough to keep a wetland wet?

- In order to keep a wetland wet, average monthly flows into the wetland should be sufficient to offset losses due to percolation and evaporation.
- A clay-lined wetland should lose no more than 0.04 inches per **hour** to percolation (based on subjective general knowledge; could easily be checked against literature)
- A wetland should lose no more than about 0.2 inches per **day** do evaporation (based on subjective general knowledge; could easily be checked against literature)
- These sum to about 1.16 inches/day.
- Accumulated over a 5000 ft2 wetland, this equates to a maximum plausible loss of 2.51 gpm

Will a wetland stay wet?

- Yes, probably. The low flow estimates (2.54 and 3.19 gpm) exceed the maximum plausible loss (2.51 gpm)
- Other factors to consider:
  - Good news
    - A really good clay liner would lose less than 0.04 in/hr
    - The wetland is heavily shaded and sheltered. So evaporative losses would probably be less than 0.2 inches/day
  - Bad news
    - The driest plausible year may be drier than the driest year in the pump record (2007-2012)
    - The source of GWP flows may be partly anthropogenic (irrigation runoff, Cal-Am leakage) and could thus be reduced in future. This seems unlikely because most years of the pump record show a decline that is consistent with a groundwater-based source.
    - Worst-case scenarios:
      - The Staff C rating curve may have changed between early 2012 and Sep 2012, and the true minimum stream flow gaging based estimate might thus be zero i.e. it might not have been flowing at all on 5-Sep-2012. This seems unlikely, since Stage D was definitely fluctuating on 5-Sep-2012.

      - The pumps could be pumping a lot more non-GWP water than estimated by City engineers, and the true longer-term minimum GWP flow could be zero.
  - Good news
    - A system could be designed for deliberate release of a small amount of Cal-am water into the wetland in case of ‘wetland dry-up emergences’.