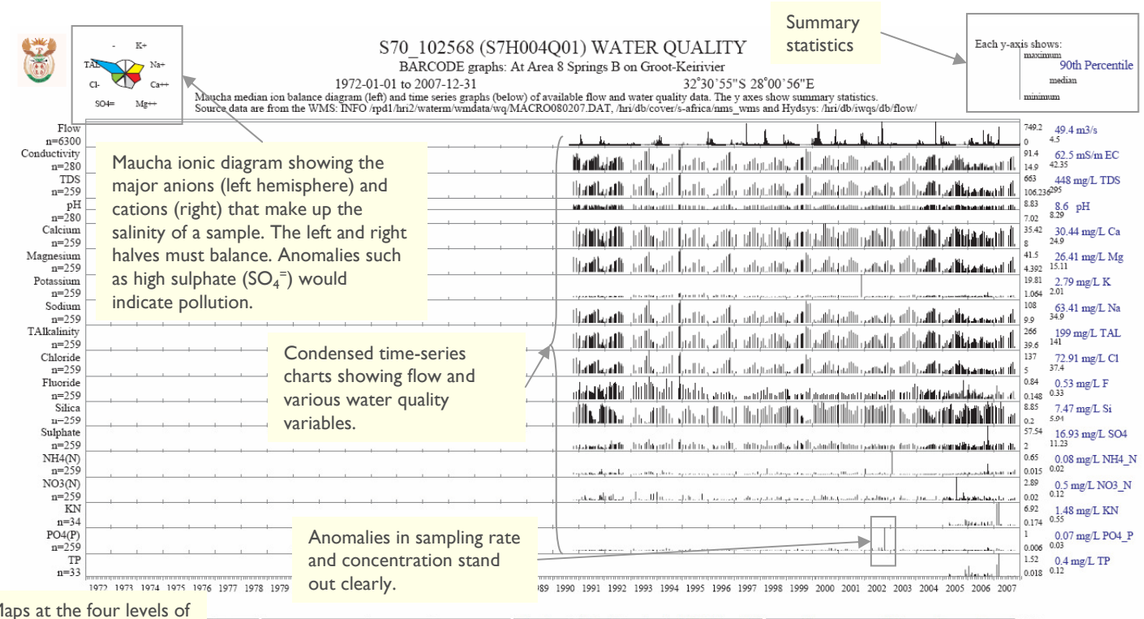
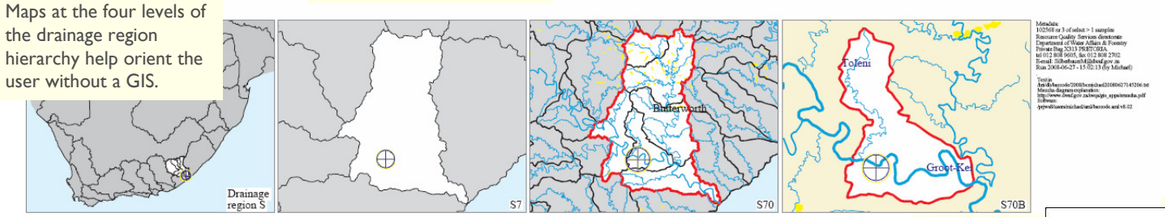
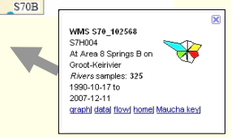


Maps at the four levels of the drainage region hierarchy help orient the user without a GIS.



Barcode summary for a single monitoring point.

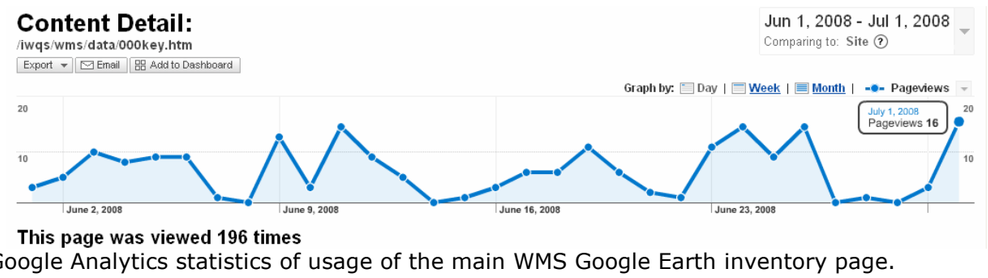


From the balloon (see overleaf), a user can open a pre-generated graphical summary of the site, download a data table or enter the Hydstra flow database.

The advantages over a conventional GIS system are Google Earth's ability to zoom rapidly from national to local scale, the frequent update of the background layers, and the ability to rapidly produce fly-through perspective views where topography emphasises the inter-relationship of pollution sources, monitoring sites and water users. Site coordinate errors are also made obvious.

Limitations of the system include the need for a more-than-entry-level PC with an Internet connection and, curiously, the raising of unreasonable user expectations regarding elevation resolution, real-time satellite images and real-time water quality data.

Integrating the water quality inventory with Google Earth has provided users of water quality data with a new way of visualising the South African data network and of sifting the inventory for useful data. Despite the limited potential audience, the site logged nearly 200 visits in June 2008. Future developments could include a tighter integration with corporate systems, including the live water quality database and the use of time-enabled markers to show how water quality at each site measures up to the applicable standards and guidelines from year to year.



Google Analytics statistics of usage of the main WMS Google Earth inventory page.

Using Keyhole Markup Language to create a spatial interface to South African water resource data through Google Earth

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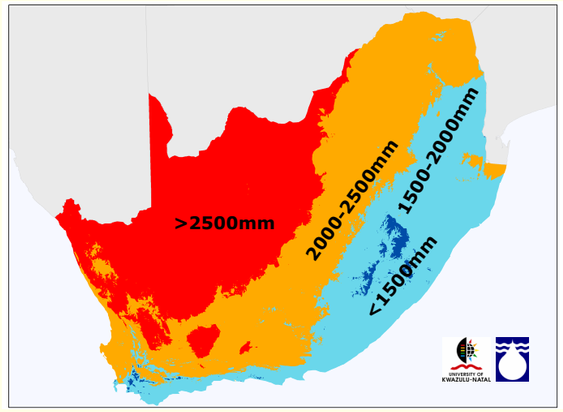
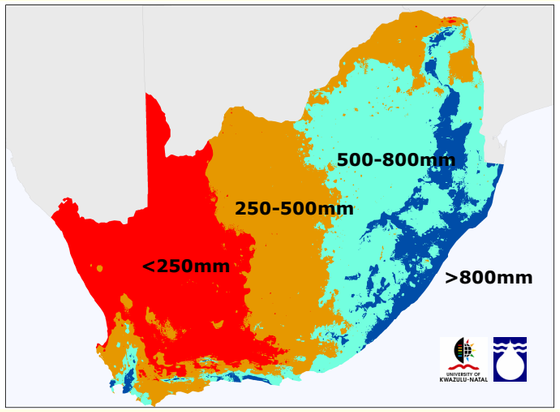
http://www.dwaf.gov.za/iwqs/wms/data/000key.htm



Annual evaporation*

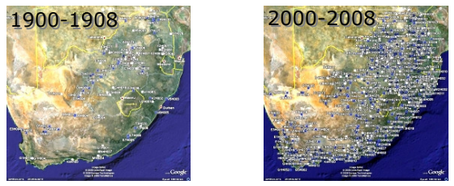


Annual rainfall*

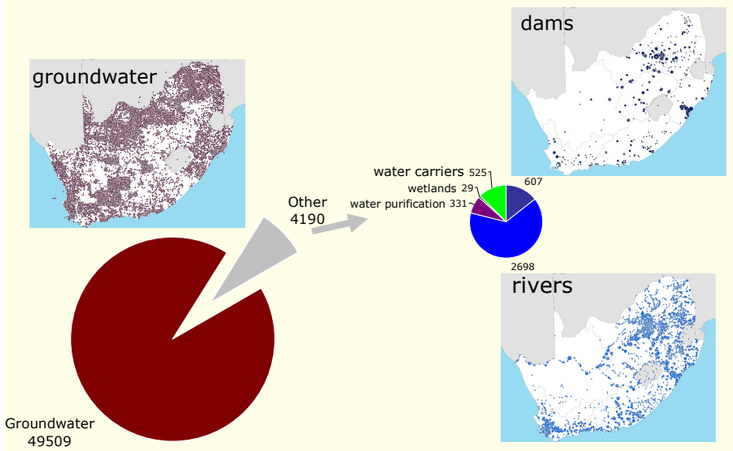
South Africa is dry, especially the north-western parts. Evaporation exceeds rainfall by a large margin and runoff is about 50mm per year.

*Data from: Schulze, R.E. (Ed). 2006. South African Atlas of Climatology and Agrohydrology. Water Research Commission, Pretoria, RSA, WRC Report 1489/1/06, Section 1.1.

Urbanisation, industrial development and mineral exploitation generate so much effluent that the parched hydrological system has no further capacity for dilution or assimilation of contaminants before the water arrives at the next user downstream. For these reasons, the Department of Water Affairs and Forestry established an extensive nationwide network of water quality monitoring sites, many of which have now been operating for thirty years or longer, associated with the century-old flow gauging network.



Flow gauging at the start of the 20th and 21st centuries.



Number of sites on WMS water quality database

Soon after Google launched Google Earth in 2005, with the Keyhole Markup Language (KML) as a method for users to overlay data, we used these tools to set up a publicly accessible spatial inventory on the departmental Internet web site (URL above), giving rapid access to several thousand surface water and groundwater monitoring site locations. Using the KML popup balloon function, users can select links to pre-generated time-series graphs of water quality, flat data files and flow data records. Maucha ionic symbols show the major ions and salinity at sites where such data are available. Date tags for the opening and closing of monitoring sites linked to the time slider enable a user to show monitoring activities for selected periods, and the hierarchical folder layout permits the selection of sites related to particular types of monitoring, such as sewage works or rivers.

Code fragment from awk script to generate KML:

```
{
  # write station range
  print "<TimeSpan id=\"ID\">" >> catfile
  print "  <begin>"dtsmp1"</begin>" >> catfile
  print "  <end>"dtsmpn"</end>" >> catfile
  print "</TimeSpan>" >> catfile
 }
# write site coordinates
print "<Point>" >> catfile
print "  <coordinates>"pntlon","pntlat",0</coordinates>" >> catfile
print "</Point>" >> catfile
print "</Placemark>" >> catfile
}
```

The first lines set the environment and folder name

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://earth.google.com/kml/2.2">
<Document>
<name>S  surface</name>
```

Define marker and balloon styles at the head of the KML script:

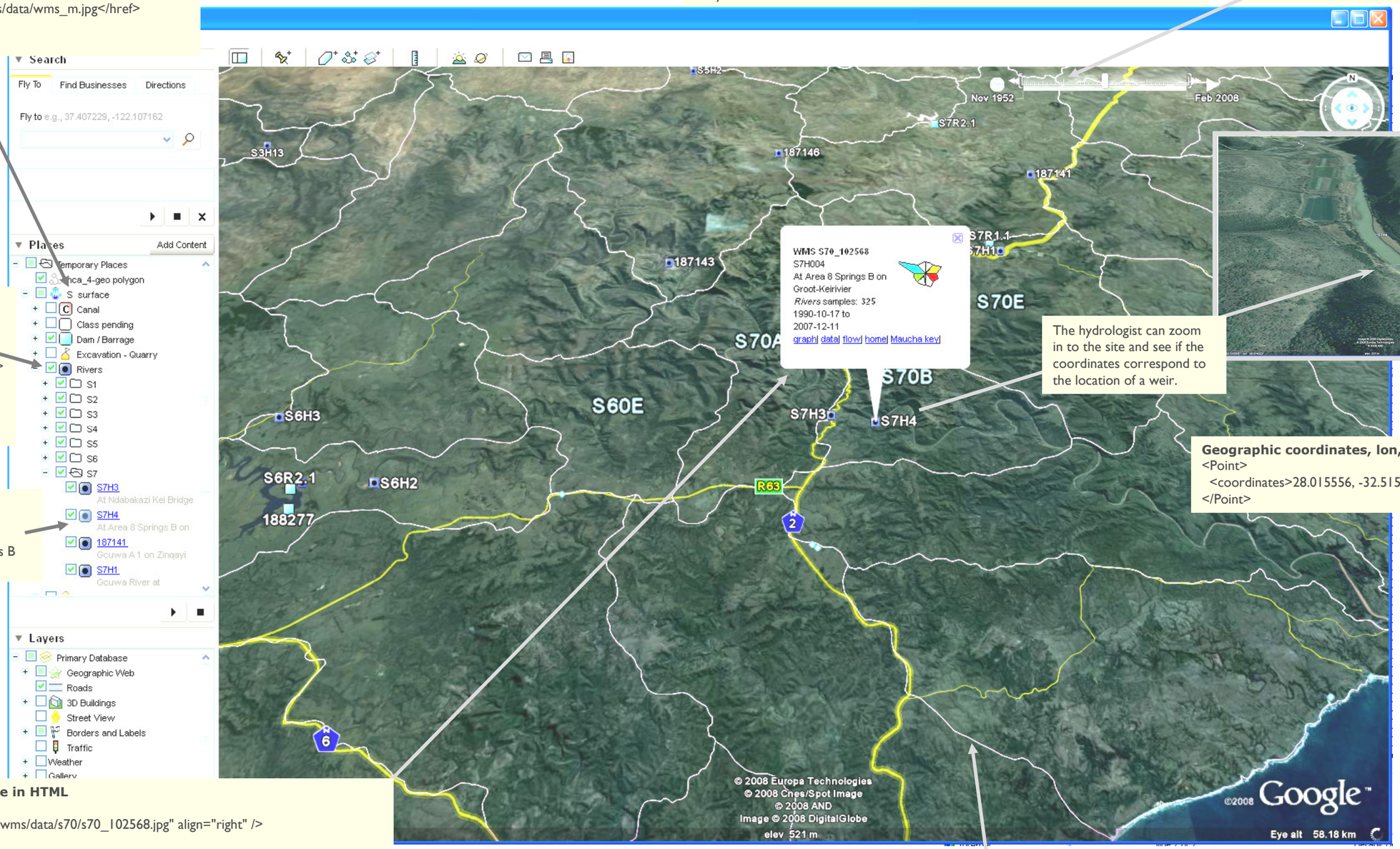
```
<Style id="hydroPlacemark">
  <IconStyle><scale>0.4</scale>
    <Icon>
      <href>http://maps.google.com/mapfiles/kml/paddle/blu-circle-lv.png</href>
    </Icon>
  </IconStyle>
  <BalloonStyle>
  <text>$[description]</text>
  <bgColor>ffffffff</bgColor>
  </BalloonStyle>
</Style>
```

Timespan links display of site to time slider

```
<TimeSpan id="ID">
  <begin>1990-10-17</begin>
  <end>2007-12-11</end>
</TimeSpan>
```

This bit is to customise the main folder icon:

```
<Style id="wmsPlacemark">
<ListStyle>
<ItemIcon>
  <href>http://www.dwaf.gov.za/iwqs/wms/data/wms_m.jpg</href>
</ItemIcon>
</ListStyle>
```



The hydrologist can zoom in to the site and see if the coordinates correspond to the location of a weir.

The Rivers folder:

```
</Folder></Folder>
<Folder>
  <name>Rivers</name>
  <styleUrl>#hydroPlacemarkL</styleUrl>
  <open>0</open>
<Folder>
  <name>S1</name>
  <open>0</open>
```

The folder entry:

```
<Placemark>
<name>S7H4</name>
<Snippet maxLines="1">At Area 8 Springs B
on Groot-Keirivier</Snippet>
```

Geographic coordinates, lon, lat

```
<Point>
  <coordinates>28.015556, -32.515278,0</coordinates>
</Point>
```

Background data:
Few institutions have the resources in-house to keep a data set like this complete and up to date.

The details within the balloon are in HTML

```
<description><![CDATA[
<img src="http://www.dwaf.gov.za/iwqs/wms/data/s70/s70_102568.jpg" align="right" />
<b>WMS S70_102568</b><br />
S7H004<br />
At Area 8 Springs B on Groot-Keirivier<br />
<i>Rivers</i> samples: <b>325</b><br />
1990-10-17 to 2007-12-11<br />
<a href="http://www.dwaf.gov.za/iwqs/wms/data/s70/s70_102568.pdf">graph</a>|
<a href="http://www.dwaf.gov.za/iwqs/wms/data/S_reg_WMS_nobor.htm#102568">data</a>|
<a href="http://www.dwaf.gov.za/hydrology/cgi-bin/his/cgihis.exe/StationInfo?Station=S7H004">flow</a>|
<a href="http://www.dwaf.gov.za/iwqs/wms/data/000key.htm">home</a>|
<a href="http://www.dwaf.gov.za/iwqs/gis_apps/maucha.pdf">Maucha key</a>|
]]></description> <styleUrl>#hydroPlacemark</styleUrl>
```

To help orientate users, we have provided supplementary background data, including South African drainage regions, in KML format.

The end:

```
 </Folder>
</Folder>
</Document>
</kml>
```