LAKE & RESERVOIR ASSESSMENTS
WHITE OAK RIVER BASIN

Catfish Lake

Intensive Survey Branch
Water Sciences Section
Division of Water Resources
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GLOSSARY

Algae Small aquatic plants that occur as single cells, colonies, or filaments. May also be referred to as phytoplankton, although phytoplankton are a subset of algae.

Algal biovolume The volume of all living algae in a unit area at a given point in time. To determine biovolume, individual cells in a known amount of sample are counted. Cells are measured to obtain their cell volume, which is used in calculating biovolume

Algal density The density of algae based on the number of units (single cells, filaments and/or colonies) present in a milliliter of water. The severity of an algae bloom may be determined by the algal density as follows:

Mild bloom = 10,000 to 20,000 units/ml
Mild bloom = 20,000 to 30,000 units/ml
Severe bloom = 30,000 to 100,000 units/ml
Extreme bloom = Greater than 100,000 units/ml

Algal Growth Potential Test (AGPT) A test to determine the nutrient that is the most limiting to the growth of algae in a body of water. The sample water is split such that one sub-sample is given additional nitrogen, another is given phosphorus, a third may be given a combination of nitrogen and phosphorus, and one sub-sample is not treated and acts as the control. A specific species of algae is added to each sub-sample and is allowed to grow for a given period of time. The dry weights of algae in each sub-sample and the control are then measured to determine the rate of productivity in each treatment. The treatment (nitrogen or phosphorus) with the greatest algal productivity is said to be the limiting nutrient of the sample source. If the control sample has an algal dry weight greater than 5 mg/L, the source water is considered to be unlimited for either nitrogen or phosphorus.

Centric diatom Diatoms are photosynthetic algae that have a siliceous skeleton (frustule) found in almost every aquatic environment including fresh and marine waters, as well as moist soils. Centric diatoms are circular in shape and are often found in the water column.

Chlorophyll *a* Chlorophyll *a* is an algal pigment that is used as an approximate measure of algal biomass. The concentration of chlorophyll *a* is used in the calculation of the NCTSI, and the value listed is a lake-wide average from all sampling locations.

Clinograde In productive lakes where oxygen levels drop to zero in the lower waters near the bottom, the graphed changes in oxygen from the surface to the lake bottom produces a curve known as clinograde curve.

Coccoid Round or spherical shaped cell

Conductivity This is a measure of the ability of water to conduct an electrical current. This measure increases as water becomes more mineralized. The concentrations listed are the range of values observed in surface readings from the sampling locations.

Dissolved oxygen A measurement of oxygen concentrations found at the sampling locations.

Dissolved oxygen saturation The capacity of water to absorb oxygen gas. Often expressed as a percentage, the amount of oxygen that can dissolve into water will change depending on a number of parameters, the most important being temperature. Dissolved oxygen saturation is inversely proportion to temperature, that is, as temperature increases, water's capacity for oxygen will decrease, and vice versa.

Eutrophic	Describes a lake with high biological productivity and low water transparency.
Eutrophication	The process of physical, chemical, and biological changes associated with nutrient, organic matter, and silt enrichment and sedimentation of a lake.
Limiting nutrient	The plant nutrient present in lowest concentration relative to need limits growth such that addition of the limiting nutrient will stimulate additional growth. In northern temperate lakes, phosphorus (P) is commonly the limiting nutrient for algal growth
Manganese	A naturally occurring metal commonly found in soils and organic matter. As a trace nutrient, manganese is essential to all forms of biological life. Manganese in lakes is released from bottom sediments and enters the water column when the oxygen concentration in the water near the lake bottom is extremely low or absent. Manganese in lake water may cause taste and odor problems in drinking water and require additional treatment of the raw water at water treatment facilities to alleviate this problem.
Mesotrophic	Describes a lake with moderate biological productivity and water transparency
NCTSI	North Carolina Trophic State Index was specifically developed for North Carolina lakes as part of the state's original Clean Lakes Classification Survey (NRCD 1982). It takes the nutrients present along with chlorophyll *a* and Secchi depth to calculate a lake's biological productivity.
Oligotrophic	Describes a lake with low biological productivity and high water transparency.
pH	The range of surface pH readings found at the sampling locations. This value is used to express the relative acidity or alkalinity of water.
Photic zone	The portion of the water column in which there is sufficient light for algal growth. DWR considers 2 times the Secchi depth as depicting the photic zone.
Secchi depth	This is a measure of water transparency expressed in meters. This parameter is used in the calculation of the NCTSI value for the lake. The depth listed is an average value from all sampling locations in the lake.
Temperature	The range of surface temperatures found at the sampling locations.
Total Kjeldahl nitrogen	The sum of organic nitrogen and ammonia in a water body. High measurements of TKN typically results from sewage and manure discharges in water bodies.
Total organic nitrogen (TON)	Total Organic Nitrogen (TON) can represent a major reservoir of nitrogen in aquatic systems during summer months. Similar to phosphorus, this concentration can be related to lake productivity and is used in the calculation of the NCTSI. The concentration listed is a lake-wide average from all sampling stations and is calculated by subtracting Ammonia concentrations from TKN concentrations.
Total phosphorus (TP)	Total phosphorus (TP) includes all forms of phosphorus that occur in water. This nutrient is essential for the growth of aquatic plants and is often the nutrient that limits the growth of phytoplankton. It is used to calculate the NCTSI. The concentration listed is a lake-wide average from all sampling stations.
Trophic state	This is a relative description of the biological productivity of a lake based on the calculated NCTSI value. Trophic states may range from extremely productive (Hypereutrophic) to very low productivity (Oligotrophic).
Turbidity	A measure of the ability of light to pass through a volume of water. Turbidity may be influenced by suspended sediment and/or algae in the water.
Watershed	A drainage area in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Overview

This river basin lies entirely within the southern outer coastal plain, where 1,233 square miles of watershed drain into the New, White Oak, Newport, and North rivers. The basin contains 267 miles of freshwater streams and rivers. The basin also contains extensive estuarine areas in Bogue and Core sounds. The White Oak River watershed is east of the New River. Much of the watershed lies within the Croatan National Forest and the Hoffman State Forest. Extensive pocosins dominate much of the landscape. Water quality is generally good in these areas. Streams flowing through these forests, including Holston Creek, Hunters Creek, and Pettiford Creek, have naturally low pH, turbidity, and conductivity values. The west side of the river is more developed, so streams on this side, such as Starkeys Creek and Webb Creek, have higher pH and conductivity values and support benthic communities more tolerant to pollution than streams on the east side of the river (NCDENR, April 2005).

Catfish Lake and Great Lake were sampled in this river basin by DWQ staff in 2009. Both of these lakes are classified as Carolina Bay Lakes and are notable for their elliptical shape, shallow, tea-colored water and low pH values due to underlying layers of peat. Catfish and Great Lakes are located within the Croatan National Forest.

Lakes in the White Oak River Basin located south and east of I-85 have been placed under a fish consumption advisory by the North Carolina Department of Health and Human Resources, Division of Public Health due to mercury contamination (http://www.schs.state.nc.us/epi/fish/current.html). Blackfish (bowfin), largemouth bass and chained pickerel (jack fish) in this area have been found to have high mercury levels.

Assessment Methodology

For this report, data from January 1, 2010 through December 31, 2014 were reviewed. Lake monitoring and sample collection activities performed by DWR field staff are in accordance with the Intensive Survey Unit Standard Operating Procedures Manual (http://portal.ncdenr.org/c/document_library/get_file?uuid=522a90a4-b593-426f-8c11-21a35569dfd8&groupId=38364) An interactive map of the state showing the locations of lake sites sampled by DWR may be found at http://portal.ncdenr.org/web/wq/ambient-lakes-map.

All lakes were sampled during the growing season from May through September. Data were assessed for excursions of the state's Class C water quality standards for chlorophyll *a*, pH, dissolved oxygen, water temperature, turbidity, and surface metals. Other parameters discussed in this report include Secchi depth and percent dissolved oxygen saturation. Secchi depth provides a measure of water clarity and is used in calculating the trophic or nutrient enriched status of a lake. Percent dissolved oxygen saturation gives information on the amount of dissolved oxygen in the water column and may be increased by photosynthesis or depressed by oxygen-consuming decomposition.

For algae collection and assessment, water samples are collected from the photic zone, preserved in the field and taken concurrently with chemical and physical parameters. Samples were quantitatively analyzed to determine assemblage structure, density (units/ml) and biovolume (m^3/mm^3).

For the purpose of reporting, algal blooms were determined by the measurement of unit density (units/ml). Unit density is a quantitative measurement of the number of filaments, colonies or single celled taxa in a waterbody. Blooms are considered mild if they are between 10,000 and 20,000 units/ml. Moderate blooms are those between 20,000 and 30,000 units/ml. Severe blooms are between 30,000 and 100,000 units/ml. Extreme blooms are those 100,000 units/ml or greater.

An algal group is considered dominant when it comprises 40% or more of the total unit density or total biovolume. A genus is considered dominant when it comprises 30% or more of the total unit density or total biovolume.

Additional data considered as part of the use support assessment include historic DWR water quality data, documented algal blooms and/or fish kills, problematic aquatic macrophytes, or listing on the EPA's 303(d) List of Impaired Waters.

For a more complete discussion of lake ecology and assessment, please go to http://portal.ncdenr.org/web/wq/ess/isu. The 1992 North Carolina Lake Assessment Report (downloadable from this website) contains a detailed chapter on ecological concepts that clarifies how the parameters discussed in this review relate to water quality and reservoir health.

Quality Assurance of Field and Laboratory Lakes Data

Data collected in the field via single or multiparameter water quality meters are entered into the Ambient Lakes Database within 24 hours of the sampling date. These data are then reviewed for accuracy and completeness within a week of entry. Data that have not been reviewed are given a 'P' code for 'Provisional' (data has been entered but not been verified for accuracy and/or completeness). Data that have been verified are given an 'A' code for 'Accepted'.

Chemistry data from the DWR Water Quality Laboratory are entered into the Lakes Database within 48 hours of receipt from the lab. As with the field data, laboratory results are coded 'P' until the entered data is verified for entry accuracy and completeness, after which, the code is changed to 'A'. Generally, laboratory data entered into the Lakes Database are verified within a week following the initial entry. Data, either laboratory or field, which appear to be out of range for the lake sampled are double checked against field sheets or the laboratory results form by the Lakes Data Administrator for possible data entry error. If there are data entry mistakes, possible equipment, sampling, and/or analysis errors, these are investigated and corrected if possible. If the possible source of an error cannot be determined, the data remains in the database. If an error is determined, the data value is removed from the appropriate database parameter field and placed in the 'Notes' field along with a comment regarding the error. Chemistry results received from the laboratory that have been given an qualification code are also entered into the 'Notes' field along with the assigned laboratory code. Laboratory qualification coded data or data which may be in error due to sampling, handling, and/or equipment problems are only entered into the 'Notes' field and never in the data field(s) in the Ambient Lakes Database.

Additional information regarding the Quality Assurance Program is covered in the Ambient Lake Monitoring Program Quality Assurance Plan. Version 2.0 (March 28, 2014) of this document is available on the ISU website (http://portal.ncdenr.org/web/wq/ess/isu).

Weather Overview for Summer 2014

May 2013 began cool for most of the state but ended warm. Precipitation in the central coastal plain, (including the White Oak River Basin), ranged from 95% to 125% of normal for March through May (Figure 1). Temperatures in June were closer to normal for the month while precipitation ranged from 95% to 200% of normal. The Town of Newport in the White Oak River Basin reported 6.57 inches of rain for the month, which was well above normal. June 2014 turned out to be warm throughout the state and ranked as the 33rd warmest June on record.

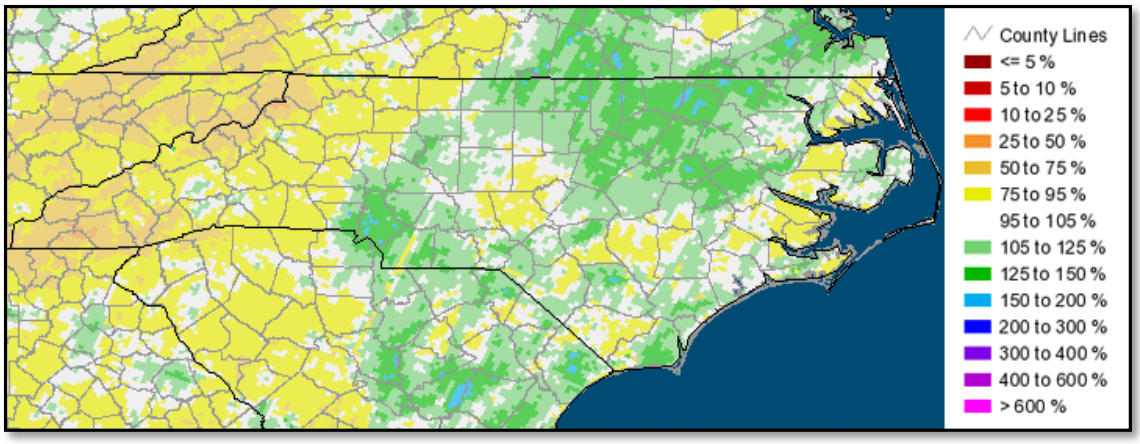

Figure 1. Percent of normal precipitation for March, April and May 2013 (State Climate Office of North Carolina, June 4, 2014, (http://nc-climate.ncsu.edu/climateblog?id=77). .

In contrast to June, July and August 2014 in North Carolina turned out to be cooler than normal. The cool mean temperatures for these months was driven by the cooler than normal maximum temperatures. On July 3, 2014, Hurricane Arthur made landfall at Cape Lookout near Beaufort, NC as a Category 2 storm. The rainfall total from this hurricane at Newport was reported at 1.43 inches. The three month (June through August) precipitation in the White Oak River Basin was 150% to 200% greater than average (Figure 2).

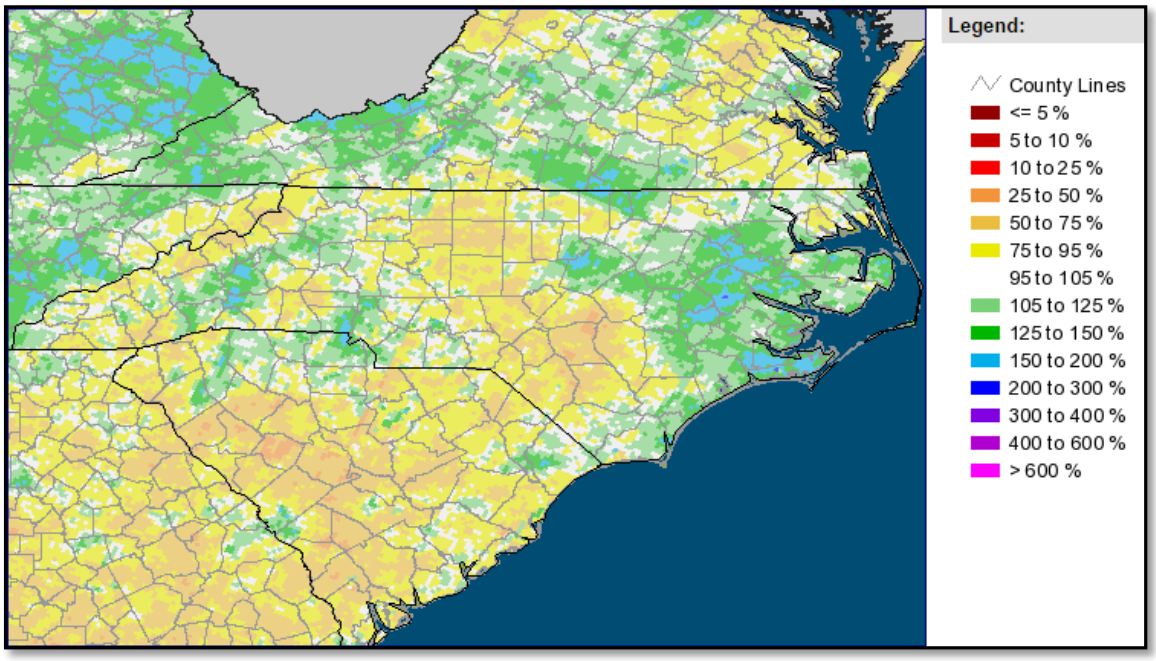

Figure 2. Percent of normal precipitation for June, July and August 2014 (State Climate Office of North Carolina, September 9, 2014, (http://nc-climate.ncsu.edu/climateblog?id=98).

After a mild summer, warm temperatures returned in late August and continued through the first week of September, then cooling again. This pattern of up and down temperatures is normal for the month of September in North Carolina as the transition from summer to fall begins. Rainfall amounts in September for the White Oak River Basin were above normal for the month.

LAKE & RESERVOIR ASSESSMENTS

HUC 03020106

Catfish Lake

Ambient Lakes Program Name	Catfish Lake	
Trophic Status (NC TSI)	Dystrophic	
Mean Depth (meters)	1.5	
Volume ($10^6 m^3$)	0.58	
Watershed Area (mi^2)	40	
Classification	C	
Stations	WOK026D	WOK026E
Number of Times Sampled	5	5

Catfish Lake is a natural blackwater Carolina Bay Lake in the Croatan National Forest. Although the lake is large (950 acres), it is uniformly shallow with a maximum depth of approximately 1.5 meters. Having no feeder stream, the lake level is maintained by rainfall and groundwater recharge. The land surrounding the lake is flat, swampy and forested. Catfish Lake is classified as C.

In 2014, DWR staff sampled Catfish Lake once monthly from May through September. As to be expected for a blackwater lake, Secchi depths were less than a meter and ranged from 0.2 to 0.4 meter (Appendix A). Surface dissolved oxygen concentrations ranged from 6.7 to 8.0 mg/L and surface water temperature ranged from 22.0 C° to 31.0 C°. Surface pH ranged from 3.8 to 4.1 s.u., which is normal for this lake.

Nutrient concentrations in Catfish Lake were similar to those previously observed in this lake. Total phosphorus ranged from 0.02 to 0.06 mg/L and total Kjeldahl nitrogen ranged from 0.49 to 0.93 mg/L. Total organic nitrogen ranged from 0.47 to 0.92 mg/L. Chlorophyll *a* raged from 2.4 to 11.0 µg/L. Turbidity values ranged from 7.9 to 45.0 NTU. Turbidity values greater than the state water quality standard of 25 NTU are due to the shallowness of the lake and wind induced wave activity that easily suspends particles of sediment and organic material into the water column.

Data from the 2014 sampling trips indicate that there have not been any substantial changes in the nutrient and physical data since 1981 and that Catfish Lake continues to maintain the same water quality as observed on the first DWQ sampling trips. Due to the dystrophic nature of this lake, an accurate North Carolina Trophic State Score cannot be accurately determined.

Great Lake

Ambient Lakes Program Name	Great Lake	
Trophic Status (NC TSI)	Dystrophic	
Mean Depth (meters)	1.0	
Volume ($10^6 m^3$)	1.20	
Watershed Area (mi^2)		
Classification	C	
Stations	WOK026G	WOK026H
Number of Times Sampled	5	5

Great Lake is a natural blackwater lake located within the Croatan National Forest. Like other Carolina Bay Lakes, it is a large (39.9 km^2), shallow (1.0 meter) body of water with acidic tannic water. Great Lake has no major tributaries and relies primarily on precipitation for recharge. This lake is classified C and is used for recreational activities such as canoeing and fishing.

Great Lake was monitored monthly from May through September 2014 by DWR staff. Surface dissolved oxygen in this lake ranged from 6.7 to 8.4 mg/L and surface water temperature ranged from 22.7 C° to 30.8 C° (Appendix A). Secchi depths for this lake are usually shallow, ranging from 0.02 to 0.03 meter in 2014. Surface pH values are naturally low and ranged from 3.7 to 4.2 s.u. Turbidity values for Great Lake ranged from 23.0 to 60.0 NTU and are due to suspended bottom sediment and organic material which are easily mixed into the water column by wind-driven wave action.

Total phosphorus in 2014 ranged from 0.03 to 0.22 mg/L, total Kjeldahl nitrogen ranged from0.40 to 0.79 mg/L and total organic nitrogen ranged from 0.39 to 0.78 mg/L. Chlorophyll *a* values ranged from 1.9 to 21.0 µg/L. Turbidity values were frequently greater than the state water quality standard of 25 NTU due to suspended bottom sediment and organic material which are easily mixed into the water column by wind-driven wave action.

Data from the 2014 sampling trips indicate that there have not been any substantial changes in the nutrient and physical data since 1981 and that Catfish Lake continues to maintain the same water quality as observed on the first DWQ sampling trips. Due to the dystrophic nature of this lake, an accurate North Carolina Trophic State Score cannot be determined.

Appendix A - White Oak River Basin Lake Data
January 1, 2010 Through December 31, 2014

Lake	Date	Sampling Station	SURFACE PHYSICAL DATA DO mg/L	Temp Water C	pH s.u.	Cond. µmhos/cm	Depth Secchi meters	Percent SAT	PHOTIC ZONE DATA TP mg/L	TKN mg/L	NH3 mg/L	NOx mg/L	TN mg/L	TON mg/L	TIN mg/L	Chla µg/L	Total Solids mg/L	Total Suspended Solids mg/L	Turbidity NTU
HUC 03020002																			
CATFISH LAKE	September 30, 2014	WOK026D	7.7	23.8	3.8	48	0.4	91.2%	0.02	0.50	0.02	0.04	0.54	0.48	0.06	2.4	59	<6.2	7.9
	September 30, 2014	WOK026E	7.5	24.1	3.8	48	0.4	89.3%	0.02	0.49	0.02	0.03	0.52	0.47	0.05	3.0	61	<6.2	8.1
	August 21, 2014	WOK026D	6.8	31.0	4.0	44	0.2	91.5%	0.03	0.58	<0.02	0.06	0.64	0.57	0.07	11.0	58	<6.2	23.0
	August 21, 2014	WOK026E	6.6	30.8	4.0	44	0.2	88.6%	0.03	0.60	<0.02	0.06	0.66	0.59	0.07	8.8	55		28.0
	July 8, 2014	WOK026D	7.0	28.5	4.1	52	0.2	90.2%	0.06	0.93	<0.02	0.02	0.95	0.92	0.03	11.0	80	16.0	45.0
	July 8, 2014	WOK026E	6.7	28.4	4.1	52	0.2	86.2%	0.06	0.90	<0.02	0.02	0.92	0.89	0.03	9.5	81	14.0	45.0
	June 17, 2014	WOK026D	6.9	29.2	3.8	55	0.3	90.1%	0.03	0.67	<0.02	<0.02	0.68	0.66	0.02	8.7	64		11.0
	June 17, 2014	WOK026E	6.9	29.1	3.8	56	0.3	89.9%	0.03	0.63	<0.02	<0.02	0.64	0.62	0.02	8.7	60	<6.2	11.0
	May 20, 2014	WOK026D	7.6	22.0	3.8	60	0.2	86.9%	0.04	0.80	<0.02	<0.02	0.81	0.79	0.02	10.0	79	8.3	25.0
	May 20, 2014	WOK026E	7.8	22.6	3.8	60	0.2	90.3%	0.04	0.83	<0.02	<0.02	0.84	0.82	0.02	9.7	78	7.7	23.0
GREAT LAKE	September 30, 2014	WOK026G	8.0	22.7	3.8	50	0.3	92.8%	0.03	0.45	<0.02	0.12	0.57	0.44	0.13	1.9	55	<6.2	29.0
	September 30, 2014	WOK026H	8.0	23.5	3.9	50	0.3	94.2%	0.03	0.42	<0.02	0.12	0.54	0.41	0.13	2.7	54		28.0
	August 21, 2014	WOK026G	6.8	30.1	4.1	46	0.2	90.1%	0.04	0.40	<0.02	<0.02	0.50	0.39	0.11	4.0	46	6.8	36.0
	August 21, 2014	WOK026H	6.7	30.8	4.1	46	0.2	89.9%	0.22	0.44	<0.02	<0.02	0.54	0.43	0.11	4.8	47	47.0	40.0
	July 8, 2014	WOK026G	7.1	28.6	4.2	54	0.2	91.7%	0.08	0.79	<0.02	0.04	0.83	0.78	0.05	11.0	72	26.0	60.0
	July 8, 2014	WOK026H	7.2	27.9	4.2	54	0.2	91.8%	0.08	0.69	<0.02	0.05	0.74	0.68	0.06	7.2	69	23.0	50.0
	June 17, 2014	WOK026G	7.3	29.6	3.7	58	0.3	95.9%	0.04	0.49	<0.02	0.05	0.54	0.48	0.06	8.1	49	49.0	23.0
	June 17, 2014	WOK026H	7.2	29.3	3.9	57	0.3	94.1%	0.04	0.45	<0.02	0.04	0.49	0.44	0.05	7.2	45	8.2	24.0
	May 20, 2014	WOK026G	8.4	23.7	4.1	61	0.2	99.3%	0.06	0.68	<0.02	0.08	0.76	0.67	0.09	21.0	60		34.0
	May 20, 2014	WOK026H	8.3	23.6	4.2	60	0.2	97.9%	0.06	0.58	<0.02	0.08	0.66	0.57	0.09	21.0	60	16.0	33.0