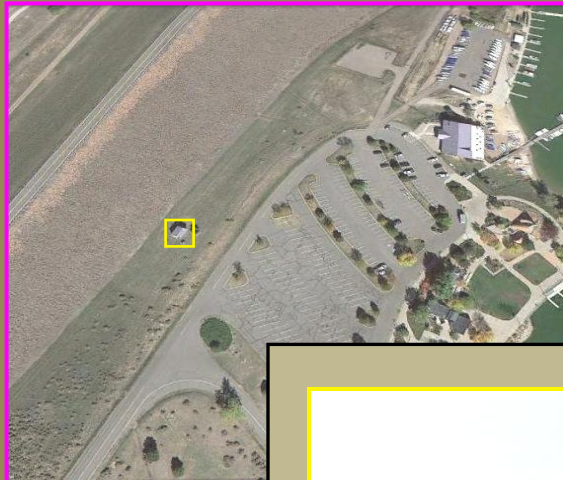
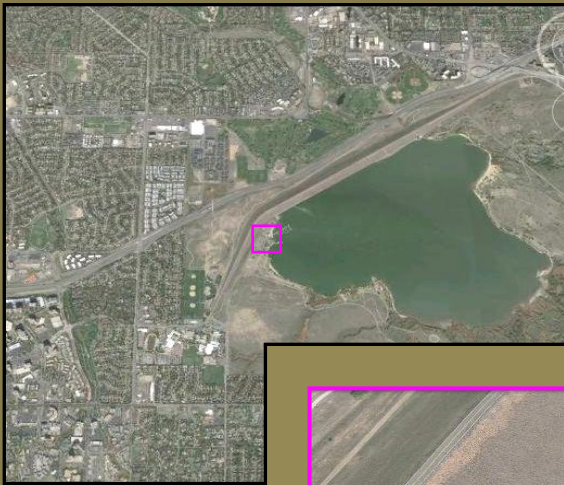

**CHERRY CREEK RESERVOIR
DESTRATIFICATION FACILITIES**

**OPERATION AND MAINTENANCE
ANNUAL REPORT
2014**



Prepared For:

**CHERRY CREEK BASIN WATER
QUALITY AUTHORITY**



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CHERRY CREEK BASIN WATER QUALITY AUTHORITY RESERVOIR DESTRATIFICATION FACILITIES OPERATION AND MAINTENANCE ANNUAL REPORT 2014

INTRODUCTION:

JRS Engineering Consultant LLC was retained under the "Capital Projects Consultant" contract to operate, and coordinate maintenance of, the destratification system including the compressor and aeration system commonly referred to as the Cherry Creek Reservoir Destratification Facilities. This is the seventh consecutive year for operation of the facilities.

START-UP PROCEDURE AND OPERATING POLICY UPDATE:

Prior to the beginning of the 2014 operating season, the Authority reviewed the prior year's Reservoir Destratification System operating policies and procedures in light of reservoir data collected from system operations for the years from 2008 through 2013. Data collected during this time period (2008 through 2013) indicates that the destratification system provides two primary benefits. One is the reduction in the dominance of blue-green algae as part of the whole algal assemblage and the second is the reduction in the periods when the reservoir is thermally stratified during the summer.¹

Water quality data collected from 2008 through 2013 suggested that operating the aeration system in early spring did not significantly affect blue-green algae (i.e.: cyanobacteria) growth, since the primary cyanobacteria growth period is from June through September when water temperatures are warmer². The aeration system additionally provides destratification of the reservoir reducing the tendency for the reservoir to "turn over" bringing up anoxic water and higher concentrations of nutrients from the reservoir floor. The data from 2008 through 2013 suggested that the reservoir begins to stratify in late-April to mid-May.

After review of the data, it was concluded that operation of the destratification system, beginning in 2014, shall be modified as follows:

- a. System start-up shall occur between the dates of May 1st and May 10th.
- b. System shut-down shall occur between the dates of November 1st and November 15th.

Additionally, operation of the destratification system shall be limited to those times when ice is not present on the reservoir, except under specific scenarios. The "Operation Policy Regarding Ice" policy adopted by the Authority's Board on February 20, 2014 is included in Appendix A. The

¹ CCBWQA January 28, 2013. *Compressor Design Basis - Daily Operation*, William P. Ruzzo, P.E., Craig Wolf, GEI.

² GEI, Consultants, Inc. January 2014. *Cherry Creek Reservoir 2013 Water Year Aquatic Biological Nutrient Monitoring Study and Cottonwood Creek Pollutant Reduction Facilities Monitoring*.

"Destratification System Compressor Start-up Procedure" approved by the Authority's Technical Advisory Committee on April 3, 2014 is included in Appendix B.

2014 START-UP:

As noted in the 2013 Reservoir Destratification System Operation and Maintenance Annual Report, the compressor shut down unexpectedly on October 22, 2013. The compressor motor had seized up and required replacement. Prior to the anticipated system start-up date, installation of a new electric motor for the compressor was completed on April 17, 2014.

Prior to the start of the 2014 operation of the destratification season, a question surfaced regarding whether, or not, the system should be started to allow for reservoir data to be collected with the destratification system in non-operational mode. This would provide additional water quality data to be collected for the in-progress reservoir modeling effort currently underway. The Authority's Technical Advisory Committee took this question under advisement and at their May 1, 2014 meeting recommended to the Authority's Board that the system not operate during the 2014 season.

The Authority's Board, at their May 15, 2014 meeting, approved a change in the Destratification Operating Policy such that the system not be placed into operation for the entire 2014 season.

It was recommended by Power Service Inc., the compressor maintenance contractor, that the new motor and compressor operate periodically during the 2014 season to maintain it in a "ready state" condition incase operation was required. In order to operate the system periodically and not allow air to enter the reservoir, piping modifications were made at the five aeration manholes, located on the north shore of the reservoir. These modifications included installation of additional valves to isolate the reservoir from the compressor piping system and allow the operator to redirect the compressed air, though the manhole system's "blow off" piping, directly to the atmosphere.

OPERATION PERIOD / INSPECTIONS:

The compressor exercise (periodic system operations) was conducted once-a-week during the summer and fall of 2014, for varying lengths of time and at various "Unload" and "Load" air pressure settings.

Prior to each compressor exercise operation an email was sent to Authority representatives, Cherry Creek State Park representatives and the Marina operator, notifying them that the compressor would be exercised that day and air would be blown off to the atmosphere. Since this "blow off" is noisy and located adjacent to the dam trail (now open across the face of the dam for Park users) three orange cones were placed adjacent to the manholes directing trail users to the dam side of the trail. See photo.



The orange cones were set up each time the system was operated. The valves in the manholes were adjusted each week so that they were exercised regularly and all compressed air was discharged through a selected aeration zone manhole blow-off. The orange cones were picked up following each weekly system exercise.

The initial compressor exercise was performed on Monday, June 23, 2014 at 8:30 AM. The table in Appendix C - 2014 Aeration Equipment Data Log summarizes the operating data recorded each week during the destratification system exercise program.

Prior to the equipment start-up each week, the electrical voltage was checked at the compressor. The amperage draw was checked during the compressor operation each week as well. This information is recorded on the table in Appendix D - 2014 Compressor Electrical Monitoring Log.

EQUIPMENT REPAIRS AND MAINTENANCE:

ROUTINE SERVICE:

A 16,000 hour service was performed on the equipment on April 16 and 17, 2014 in conjunction with installation of the new compressor electric motor. The service performed included an oil change (Roto Z synthetic oil), replacement of the oil filter, oil diaphragm, oil breather, outlet check valve, air inlet parts, air filter replacement, crankcase breather replacement and cleaned all ducts, fans and heat exchangers.

AIR PIPING REPAIRS AND REPLACEMENT:

A recommendation in the 2013 Destratification System Evaluation Report³ included replacement of an exposed section of 4-Inch HDPE diameter air piping outside the exterior wall of the compressor building. The report identified this exposed HDPE pipe as a safety issue. On April 10, 2014, prior to the start of the 2014 aeration season, this length of vertical exposed HDPE pipe from the exterior wall of the compressor building to a point in the horizontal piping underground adjacent to the building was replaced.

Piping modifications were completed in each of the five aeration system distribution manholes located adjacent to the dam trail along the face of the dam. The piping within the manhole was modified to remove the inoperable flow meters, the existing gate valves and a majority of existing the HDPE pipe. New galvanized pipe and new ball valves were installed in each manhole. The new piping and valve configuration provides a positive air shut-off to the reservoir and allows air to be blown-off to the atmosphere at each manhole. This work was completed on June 11, 2014.

ELECTRICAL USAGE / RATE SCHEDULE:

During the 2014 destratification system operation season, it was noted that the Xcel billings appeared to be high based on the limited compressor usage. Following a brief investigation, it was determined that two electrical rate schedules are available to the Authority based on usage.

Schedule SG (Secondary General Service) includes higher monthly demand charges and lower kilowatt usage rates. Operation under this billing rate schedule is more economical when operating the destratification system continuously.

Schedule SGL (Secondary General Low-load Factor) includes lower monthly demand charges and higher kilowatt usage rates. Operation under this billing rate schedule is more economical when operating the destratification system in the exercise mode.

³ Eaton Energy Solutions September 27, 2013. *Cherry Creek Reservoir, Cherry Creek State Park, CO., Destratification System Evaluation Report.*

The Authority was being billed based on Schedule SG, which would have been more cost effective with full time operation of the system. The account was immediately switched to Schedule SGL for the 2014 season.

The customer service representative from Xcel stated that since the Authority operates the system seasonally, there isn't an issue with changing from one rate schedule to the other during the year to "best fit" the system's seasonal operation. A paragraph will be added to the Destratification System Compressor Start-up Procedure to outline the procedure to establish the Authority's billing rate schedule to the optimum rate schedule for the system's operational status.

RECOMMENDATIONS:

The following recommendations are provided for consideration to improve system operation:

- Determine if the destratification system should operate in 2015 and if so what that operation procedure should be.
- Install a meter to measure and monitor the total volume and rate of air flow (from 2012 annual report).
- Install a pressure switch on the discharge pipeline. The switch initiates an alarm when the discharge pressure decreases to a minimum set-point. A "Low Pressure Alarm" would call out regardless of the reason for a compressor shut down: high temperature, power interruption, air line leak, etc (from 2012 annual report).
- Incorporate the air conditioner or a form of mechanical cooling for the oil heat exchanger on a permanent basis (from 2012 annual report).

APPENDIX A - OPERATION POLICY REGARDING ICE

Cherry Creek Basin Water Quality Authority
Cherry Creek Reservoir Destratification System
Operation Policy Regarding Ice
Board Adopted Version
February 20, 2014

Operation of the Cherry Creek Reservoir Destratification System shall be limited to those times when ice is not present on the Reservoir, except under the following scenario:

- System Start-up before ice is off the Reservoir if either:
 1. The Authority has determined that doing so is in the best interest of the Authority to assist in protection of the constructed Pollutant Reduction Facilities (PRF's)¹.
 2. The Park Manager has determined that doing so is in the best interest of the Park to assist in protecting the Park facilities such as the marina, constructed PRF's, other Park improvements or the unprotected shoreline. Or, has determined that doing so would alleviate a dangerous condition/situation for Park users².

All start-up and shut-down notifications, decisions, procedures, detail, dates and conditions shall be documented in the Destratification Facilities - Operation and Maintenance Annual Report.

Start-up of the destratification system each year shall be performed in accordance with the "Compressor Start-up Procedures".

The Authority, at its sole discretion, may shut the destratification system down at any time during the aeration season if, or when, there is no water quality benefit to continued operation.

¹ If floating ice is observed on the Reservoir and it is believed that constructed PRF's will be damaged by the ice, the Authority, authorizes the Authority Manager after consultation with the Authority's engineering, water quality and legal consultant, and the TAC chair, to make the determination on start-up. Prior to start-up of the destratification system, the notification procedures outlined in the "Compressor Start-up Procedure" shall be completed and documented in writing (by email, letter or fax). All start-up decisions, detail and notifications shall be documented and included in the annual report. Board and TAC members shall be notified by email if the system is started under this condition.

² If the Park Manager notifies the Authority, in writing (by email, letter or fax), that starting the system while ice is on the Reservoir is in the best interest of the Park, the Authority Manager, with assistance of the Authority engineering and water quality consultants, will confirm that water quality conditions are satisfactory prior to start-up. The Park Manager shall then perform the notification procedures outlined in the "Compressor Start-up Procedure" and provide copies of the written notifications to the Authority Manager. All written notifications shall state the Reservoir conditions and concern prompting the request. Parks shall assist the Authority to confirm no persons are on the ice when the system is started. Once the ice condition is no longer an issue as determined by the Park Manager, the Authority, at its sole discretion, may elect to shut the destratification system down.

APPENDIX B - DESTRATIFICATION SYSTEM COMPRESSOR START-UP PROCEDURE

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CHERRY CREEK RESERVOIR DESTRATIFICATION SYSTEM
COMPRESSOR START-UP PROCEDURE
March 25, 2014

Start-up Criteria:

Operation of the Cherry Creek Reservoir Destratification System shall be in accordance with the terms, conditions and policy set forth in the Destratification System - Operation Policy Regarding Ice; adopted by the Authority's Board on February 20, 2014. This policy requires that operation of the system be limited to those times when ice is not present on the Reservoir, except when early start-up is determined necessary as outlined in the operation policy.

An on-site inspection shall be conducted by the Authority's System Operator to verify that ice is not present on the Reservoir prior to start-up. In the event that early start-up is required while ice is on the reservoir, the Authority's System Operator shall confirm that all notifications, responses and other details are completed in accordance with the Destratification System - Operation Policy Regarding Ice. The Authority's System Operator shall then log the detail of the start-up procedure in the Cherry Creek Reservoir Destratification Facilities Operation and Maintenance Annual Report.

Start-up Procedure:

The system shall be started, following the pre-start system check outlined in the Operation and Maintenance Manual, utilizing the soft-start procedure as follows:

Starting the system shall be accomplished by opening up one aeration zone at a time with some interval (i.e.: 2 to 4-hours) before opening the next zone. A soft start also includes a lower than normal unload / load pressure for start-up of the initial zone (typically 45.0 psi / 39.0 psi) and then increasing the pressure when each additional zone is brought on-line, over the start-up period as necessary to cause bubbles to rise to the surface, until the unload / load pressure reaches 52.0 psi / 48.0 psi with all five zones operating.

Start-up / Shut-down Schedule:

System start-up shall occur between the dates of May 1st and May 10th to provide the system operator flexibility in scheduling the start-up, unless early start-up is required.

System shut-down shall occur between the dates of November 1st and November 15th.

Start-up Conditions with Ice on the Reservoir:

When it becomes necessary to operate the system before ice is off the Reservoir then three conditions need to be considered during start up:

1. The rising bubbles may bring anoxic water from the bottom to the surface *under the ice*, trapping the fish in an unsafe habitat. Past experience has shown that by using the "soft start" approach, which starts the aeration lines one at a time under or near open water areas, then a hazardous fish environment was not created. Dissolved Oxygen profile information will be provided and analyzed as a part of the start-up procedure.
2. Starting the system prior to March 1 potentially creates problems for CCSP. The aquatic nuisance control program (i.e.: zebra and quagga mussel inspection) requires that all boats be inspected, which begins on March 1st.
3. Starting the system while ice is present on the Reservoir requires written notification to the following parties and written confirmation of their concurrence to start the system while ice is on the Reservoir. All written notifications and confirmations shall be in the form of email, fax or letter.
 - *Cherry Creek State Park (CCSP) Park Manager.*
 - *Colorado Parks and Wildlife (CPW) Sr. Aquatic Biologist; Platte Basin.*
 - *Marina Operator.*
 - *Cherry Creek Basin Water Quality Authority Manager.*



Memorandum

To: CCBWQA Technical Advisory Committee and Destratification Sub-committee
From: James R. Swanson, PE- JRS Engineering Consultant, LLC, William P. Ruzzo, PE, LLC
Date: March 18, 2014
Subject: Destratification System Compressor Start-up Procedure

Presented in the memorandum is a summary of the Authority's destratification system compressor start-up procedure, discussion of prior years practice, review and discussion of the water quality data from prior year's operation and resulting start-up procedure modifications to optimize water quality conditions and system operating efficiency.

Background:

The destratification system consists of a rotary screw air compressor, piping and 116 air diffusers placed at the floor of the deepest part of the reservoir. The system works by pumping air into the bottom of the reservoir providing mixing and oxygenation of the water. The Authority began operation of the destratification system on April 4, 2008. Prior to initial start-up in 2008, it was determined the aeration system would be operated for as long of a season as practical, typically from approximately March 1st through the end of November¹. In doing so, continued water quality data monitoring developed a consistent baseline from which to evaluate, and predict, the benefits of operating the aeration system and to manage various water quality parameters within the reservoir. Specific start-up and shut-down dates were previously determined annually based on the Reservoir water quality data, weather patterns, ice cover and other factors.

It was found the destratification system needed to operate for approximately two weeks to attain full development of the water column circulation pattern, thereby reducing thermal stratification.

Data collected during this time period (2008 through 2013) indicates that the destratification system provides two primary benefits. One is the reduction in the dominance of blue-green algae as part of the whole algal assemblage and the second is the reduction in the periods when the reservoir is thermally stratified during the summer.²

Data Results and Trends:

Water quality data collected from 2008 through 2013 suggests that operating the aeration system in early spring does not significantly affect blue-green algae (i.e.: cyanobacteria) growth, since the primary cyanobacteria growth period is from June through September when water temperatures are warmer³. A summary of this data is attached. Cyanobacteria are generally most active at temperature ranges above 15° C, which makes them most active in the summer months. This trend is supported by comparing chlorophyll a concentrations for pre and post-aeration system conditions, as shown in the attached data. Also, the daily maximum ambient temperatures near the reservoir are generally below 15° C from October through April (see attached data) providing further support for a later season system start date.

¹ March 1 is the start of the boating season. Allowing boater access to the Reservoir before March 1 required Parks to have their safety and ANS (Aquatic Nuisance Species, such as Quagga and Zebra mussels) inspection personnel in place sooner, which potentially created an administrative problem. Starting the system before March 1 could clear the ice cover on the Reservoir and allow boaters to launch before Parks was ready.

² CCBWQA January 28, 2013. *Compressor Design Basis - Daily Operation*, William P. Ruzzo, P.E., Craig Wolf, GEI.

³ GEI, Consultants, Inc. January 2014. *Cherry Creek Reservoir 2013 Water Year Aquatic Biological Nutrient Monitoring Study and Cottonwood Creek Pollutant Reduction Facilities Monitoring*.

The aeration system additionally provides destratification of the reservoir reducing the tendency for the reservoir to "turn over" bringing up anoxic water and higher concentrations of nutrients from the reservoir floor. The data from 2008 through 2013 suggests that the reservoir begins to stratify in late-April to mid-May. This varies from year-to-year, typically caused by an influx of snowmelt in the early spring and/or cold rainfall in the warm summer months causing temperature stratifications. It is noted that the aeration system is effective in minimizing stratification within the reservoir.

Conclusions:

1. The aeration system should be operational on, or about, May 15th to minimize the dominance of the blue-green algae (cyanobacteria) growth in the reservoir.
2. The aeration system should be started on, or about, May 1st to provide a fully developed water column circulation pattern by mid-May.
3. Operation of the destratification system beyond mid-November isn't supported by ambient temperature or algal population data for cyanobacteria or diatoms.

In summary, operation of the destratification system shall be modified as follows:

- a. System start-up shall occur between the dates of May 1st and May 10th.
- b. System shut-down shall occur between the dates of November 1st and November 15th.

APPENDIX C - 2014 AERATION EQUIPMENT OPERATING DATA LOG

APPENDIX C - 2014 AERATION EQUIPMENT OPERATING DATA LOG

DATE	DAY OF WEEK	TIME OF DAY	DAILY RUNTIME ¹ MINUTES	ELECTRIC METER KWHRS		UNIT HOURS				LOAD RELAY COUNTS (X1000)		UNIT STARTS	TEMPERATURE; DEGREES FAHRENHEIT (°F)					OUTLET PRESSURE	
				READING	USAGE	RUNNING	ELAPSED	LOADED	ELAPSED	TOTAL	ELAPSED		OUTSIDE	AMBIENT	OUTLET	ELEMENT	OIL	UNLOAD	LOAD
23-Jun	Monday	8:30 AM	103	47444		35106		15298		4984		521	73	69	92	445	122	45.0	40.0
2-Jul	Tuesday	10:30 AM	102	47448	4	35107	1	15300	2	4984	0	522	77	75	95	474	124	47.0	44.0
11-Jul	Friday	11:30 AM	62	47452	4	35108	1	15301	1	4984	0	523	91	82	107	485	123	49.5	47.0
16-Jul	Wednesday	7:50 AM	66	47454	2	35109	1	15301	0	4984	0	524	61	69	76	445	107	52.0	47.0
21-Jul	Monday	6:50 AM	181	47456	2	35110	1	15302	1	4984	0	525	63	69	79	473	111	52.0	48.0
29-Jul	Tuesday	7:00 AM	138	47461	5	35115	5	15305	3	4985	1	526	64	77	98	492	128	50.0	47.0
5-Aug	Tuesday	7:40 AM	77	47466	5	35116	1	15306	1	4985	0	527	67	73	88	463	120	50.0	47.0
13-Aug	Wednesday	8:00 AM	53	47468	2	35116	0	15306	0	4985	0	528	69	79	95	470	126	49.5	47.0
18-Aug	Monday	11:30 AM	136	47470	2	35118	2	15307	1	4986	1	529	84	92	108	503	138	49.5	47.0
27-Aug	Wednesday	12:00 AM	166	47475	5	35122	4	15309	2	4986	0	530	72	88	104	463	133	49.5	47.0
4-Sep	Thursday	11:30 AM	89	47479	4	35124	2	15310	1	4986	0	531	68	80	100	478	129	49.5	47.0
11-Sep	Thursday	1:28 PM	79	47485	6	35125	1	15311	1	4987	1	532	47	60	97	445	109	49.5	47.0
22-Sep	Monday	3:50 PM	270	47493	8	35130	5	15313	2	4988	1	533	73	84	101	479	131	49.5	47.0
30-Sep	Tuesday	2:40 PM	208	47499	6	35133	3	15315	2	4988	0	534	61	72	91	474	122	51.0	48.0
7-Oct	Wednesday	11:10 AM	150	47504	5	35136	3	15317	2	4988	0	535	56	69	91	492	125	51.0	48.0
15-Oct	Wednesday	11:20 AM	143	47508	4	35138	2	15318	1	4989	1	536	72	81	97	472	129	51.0	48.0
23-Oct	Thursday	2:45 PM	175	47513	5	35141	3	15319	1	4989	0	537	75	78	89	444	120	51.0	48.0
30-Oct	Thursday	11:10 AM	114	47516	3	35143	2	15320	1	4989	0	538	59	61	77	431	109	51.0	48.0

Footnote 1 - Daily Runtime recorded by Mission Controller.

APPENDIX D - 2014 ELECTRICAL MONITORING LOG

APPENDIX D - 2014 COMPRESSOR ELECTRICAL MONITORING LOG

DATE	DAY OF WEEK	MOTOR VOLTAGE						MOTOR AMPERAGE						OUTLET PRESSURE	
								LOADING			UNLOADING			UNLOAD	LOAD
		L ₁ - G	L ₂ - G	L ₃ - G	L ₁ - L ₂	L ₁ - L ₃	L ₂ - L ₃	L1	L2	L3	L1	L2	L3		
23-Jun	Monday	294	287	292	504	505	502	118	115	116	71	69	68	45.0	40.0
2-Jul	Tuesday	284	286	289	496	494	494	119	114	114	69	68	66	47.0	44.0
11-Jul	Friday	287	287	293	499	500	499	117	115	118	69	68	67	49.5	47.0
16-Jul	Wednesday	284	288	290	496	496	495	123	120	122	68	68	68	52.0	47.0
21-Jul	Monday	287	286	287	497	497	495	126	119	122	71	66	66	52.0	48.0
29-Jul	Tuesday	286	285	287	495	497	495	123	118	122	71	67	67	50.0	47.0
5-Aug	Tuesday	285	284	286	495	495	493	124	116	121	71	66	66	50.0	47.0
13-Aug	Wednesday	285	284	285	493	493	492							49.5	47.0
18-Aug	Monday	286	286	288	496	495	495	122	117	120	70	66	66	49.5	47.0
27-Aug	Wednesday	283	284	285	492	492	492	123	117	120	70	66	67	49.5	47.0
4-Sep	Thursday	285	284	285	493	492	490	121	113	118	69	64	66	49.5	47.0
11-Sep	Thursday	287	285	286	494	495	492	123	115	120	71	64	67	49.5	47.0
22-Sep	Monday	286	285	286	495	495	493	123	117	120	71	66	67	49.5	47.0
30-Sep	Tuesday	288	287	288	497	499	496	124	115	117	71	65	65	51.0	48.0
7-Oct	Wednesday	287	286	288	496	497	495	124	116	123	72	66	69	51.0	48.0
15-Oct	Wednesday	287	285	286	494	496	493	122	117	120	70	65	66	51.0	48.0
23-Oct	Thursday	284	284	287	493	493	492	122	115	118	69	66	63	51.0	48.0
30-Oct	Thursday	288	288	290	499	499	498	122	117	120	71	67	67	51.0	48.0