Long-Term Water-Quality Data Collection Associated with Wichita’s Primary Drinking Water Source: Cheney Reservoir, South-Central Kansas, 1966–2019

Prepared in cooperation with the city of Wichita
Wichita Water Sources

Cheney Reservoir and the *Equus* Beds Aquifer

USGS water data collection since the 1920s; long term datasets for both projects

North Fork Ninnescah River is Cheney’s major inflow

Little Arkansas River is source water for *Equus* Beds Aquifer Storage and Recovery (ASR)
Study Area: Cheney Reservoir

Constructed in 1965
167,000 acre-ft capacity
(Kansas Biological Survey, 2010)
Area: 15.5 mi² or 9,940 ac
North Fork Ninnescah River is main tributary
Watershed land use predominately agricultural
Nutrients & sediment are primary pollutants (non-point)
Stratifies for short periods
Taste-&-odor issues
Selected Background Highlights

Cheney Reservoir Task Force:
- Formed in 1992 due to taste- & odor occurrences
- Prepared a pollution management plan & established stream water-quality goals
- Concentrations during baseflow & runoff conditions have been well documented (Stone and others, 2009 & 2013)
- Long-term trends in concentrations have been more difficult to assess due to hydrologic variability & length of data collection

Sediment Loading:
- Sedimentation is reducing storage capacity
- Substantial sediment loads enter the reservoir over very short periods of time (Stone and others, 2015)

Table 1. Cheney Reservoir Task Force mean stream water-quality goals for total suspended solids, dissolved nitrate as nitrogen, and total phosphorus concentrations in Cheney Reservoir watershed streams during base flow, runoff, and long-term streamflow conditions. *

<table>
<thead>
<tr>
<th>Water-quality constituent</th>
<th>Mean water-quality goal (milligrams per liter)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base flow</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>20</td>
</tr>
<tr>
<td>Dissolved nitrate as nitrogen</td>
<td>0.25</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Selected Background Highlights: Cheney Reservoir Taste-&-Odor Events

Taste- & odor events prompted city of Wichita to conduct more studies

Upgraded to ozone treatment in 2006 to control event effects

Early event warning would allow optimization of ozone dosage & cost savings

Occasional recreational advisories & warnings since KDHE began HAB monitoring program in 2010
Selected Long-Term Data Collection: Cheney Inflow

Discrete water-quality
- Dissolved solids & major ions
- Total suspended solids & sediment
- Nutrients
- Bacteria

Continuous streamflow

Continuous water-quality
- Specific conductance
- pH
- Water temperature
- Turbidity
- Dissolved oxygen

Data available at nwis.waterdata.usgs.gov/nwis

Streamflow measurement, in-situ water-quality monitor, & water-quality sampling at North Fork Ninnescah River above Cheney (USGS site number 07144780)
Selected Long-Term Water-Quality Data Collection: Cheney Reservoir

Discrete
- Dissolved solids & major ions
- Total suspended solids & sediment
- Nutrients
- Chlorophyll
- Bacteria
- Microcystin
- Geosmin
- Actinomycetes
- 2-methylisoborneol (MIB)

Continuous
- Specific conductance
- pH
- Water temperature
- Turbidity
- Dissolved oxygen
- Nitrate
- Chlorophyll
- Phycocyanin
- Cyanobacteria

Data available at nwis.waterdata.usgs.gov/nwis
Selected Long-Term Data Analysis

Long-term trend analysis
EGRET (Exploration & Graphics of RivEr Trends)
Hirsch & De Cicco, 2015: pubs.usgs.gov/tm/04/a10/
WRTDS (Weighted Regressions on Time, Discharge, & Season)
WBT (WRTDS Bootstrap Test) – assigns trend likelihood

Surrogate model development
National Real-Time Water Quality at nrtwq/usgs.gov
In-situ monitor & concomitant discrete water-quality data

Regression equations
Compute concentrations or exceedance probabilities in real time
Concentrations & streamflow → long-term loads

Composed instantaneous total phosphorus concentration in North Fork Ninnescah River above Cheney Reservoir, KS

Percent change exceeds criteria

Data pulled 03:08:19 08:51.
The chart is interactive: you can mouse over to highlight individual values. You can click and drag to zoom. Double-clicking will zoom you back out. Shift-drag will pan.

EXPLANATION
- Blue: Discharge
- Black: Measured or computed water-quality constituent
- Silver: 90-percent prediction interval for computed value
- Red: Value obtained from discrete sampling and analysis
- Orange: Load calculated using laboratory analysis and discharge
- Dotted: Water-quality criteria
Kansas Water Science Center Cheney Project & USGS National Priorities

Water Mission Area: collect and disseminate reliable, impartial, and timely information that is needed to understand the Nation’s water resources.

- **Water Prediction Work Program**
  - Surrogate models
  - Real-time water-quality constituent computation

- **Next Generation Water Observing System**
  - Water-quality monitors with multiple sensors
  - Temperature, pH, dissolved O₂, specific conductance, turbidity
  - Nitrate, fDOM, chlorophyll, & phycocyanin fluorescence

- **Integrated Water Availability Assessments**
  - Surface water quantity
  - Surface water quality
Selected Long-Term Trend Results: Cheney Reservoir Inflow Nutrients 1999–2017

**Total phosphorus:**
Frequency that flow-normalized concentration is trending up in bootstrap replicates: 0.89
- *upward trend likely*
  - 1999 flow-normalized: 0.125 mg/L
  - 2017 flow-normalized: 0.158 mg/L
  - Trend magnitude: 26% increase

**Nitrate:**
Frequency that flow-normalized concentration is trending down in bootstrap replicates: 0.86
- *downward trend likely*
  - 1999 flow-normalized: 1.33 mg/L
  - 2017 flow-normalized: 1.12 mg/L
  - Trend magnitude: 16% decrease
Long-Term Trend Results: Cheney Reservoir Inflow Solids & Sediment 1999–2017

Total suspended solids:
Frequency that flow-normalized concentration is trending up in bootstrap replicates: 0.84

*upward trend likely*
1999 flow-normalized: 60.9 mg/L
2017 flow-normalized: 83.1 mg/L
Trend magnitude: 36% increase

Suspended sediment:
Frequency that flow-normalized concentration is trending up in bootstrap replicates: 0.99

*upward trend highly likely*
1999 flow-normalized: 111 mg/L
2017 flow-normalized: 175 mg/L
Trend magnitude: 57% increase
Long-Term Suspended-Sediment Loads into Cheney Reservoir: 18% of Total Load in 1979

Modified from Stone and others, 2015
Cheney Reservoir Event Seasonality 2001-16

Detections: Cyanobacteria, 84% of samples
Microcystin, 52% of samples
Geosmin, 31% of samples

Cyanobacterial abundances generally peaked in late summer/early fall

Microcystin had maximum concentrations in summer

Geosmin seasonal patterns less consistent

Changing environmental conditions affect seasonal patterns in cyanobacteria, microcystin, and taste- & odor compounds
Cheney Reservoir Microcystin Logistic Regression Model

- Exceedance probability
- Microcystin (μg/L)
- Threshold

Probability of exceeding 0.1 μg/L vs. Microcystin (μg/L)

January 2013 to February 2014

USGS
Summary and Conclusions: Long-Term Data Collection

Long-term inflow trend analysis indicates
- Total suspended solids is likely increasing
- Total phosphorus is likely increasing
- Sediment is highly likely increasing
- Nitrate is likely decreasing

Large sediment loads delivered in substantially small periods of time
- Quantifying water-quality improvements presents challenges when transport occurrences are associated with large catastrophic events

Continued data collection necessary for model updates

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https://www.usgs.gov/centers/kswsc/science

Cheney Reservoir 2012, photo by Garrett Gabriel

Long-term data collection critical to understanding trends & processes