Weather Conditions & Hay Moisture
Potential Implications for Hay Quality

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Losses During Haymaking Accelerate With Lower Moisture Hay

Estimated Harvest Losses of 20-25%

From Pitt, 1979; Hundtoft, 1965; Rotz, 1989
Humidity & Hay Moisture

- **Equilibrium Moisture**
  - Hay Placed in Constant Humidity Environments
  - Allowed to Equilibrate
  - Measure Moisture Content

- **Purpose**
  - Storage Conditions
  - Quality
  - Trade

  ![Graph showing moisture content vs. relative humidity with two lines for different temperatures.]

  Source: Pitt, 1990; Hill et al., 1976

- Moisture increases with humidity
- Moisture decreases with temperature
Relevance to Arizona Hay

- Lab testing indicates good agreement
- Leaves & stems similar
- Low humidity extension
Hay Operations: Moisture Recommendations

**AZ Baling Moisture Range**

- **RH: ~50-70%**
- **RH: >85%**

**Recommended Moisture for Raking**

- **RH: >85%**
The Challenge!

- Average maximum relative humidity barely in bailing range in May & June
- Even more challenges for raking moisture
Near Surface Humidity
Clear, Calm Night

- Water vapor escaping from soil helps humidify near surface atmosphere
- Cooler near surface temperature increase relative humidity
Higher Humidity Near Surface

Wind mixes up the stratified near surface atmosphere, greatly reducing near surface humidity at night.
Measuring Hay Drydown
September Cutting, Harquahala, AZ

Alfalfa Moisture Following Cutting

- Rapid drying during daytime
- Rehydration at night
Day 4
A Closer Look at Night Rehydration

-Hay moisture responds rather quickly to change in humidity at night
-Hay approaches 12% moisture at 70% near surface relative humidity
How Fast Can Hay Respond to Change in Humidity?

Oven Dried Hay Transferred to Environment With 75% Relative Humidity

--Leaf Moisture Increased to 10% in ~35 Minutes
--Stem Moisture Increased to 10% in ~75 Minutes
Raking & Moisture

Raking at 40%+ moisture minimizes losses

From Pitt, 1979; Hundtoft, 1965; Rotz, 1989

Arizona hay reaches this level quickly and does not rehydrate to 40% without dew
Self Humidification

<table>
<thead>
<tr>
<th>Hay Moisture: ~40%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
</tr>
<tr>
<td>Leaves</td>
</tr>
<tr>
<td>Stems</td>
</tr>
</tbody>
</table>

Early in dry down process, slower drying stems will have higher equilibrium humidity and should humidify swath/leaves at night.
Possible Management Options

• Humidity Monitoring
  • When to Bale

• Cultural Practices
  • Soil Moisture
  • Windrow Management

• Artificial Humidification
  • Light Water Applications
  • Steam System
  • Dew Simulator

Early Windrow Steam System
Portable Humidity Monitors
Remote Field Assessment

- Humidity Sensor
- Datalogger
- Cell Phone
- Alerts/Alarms
  - At Selected Humidity
  - Calls/Texts
- Set Point
  - 45-55% Relative Humidity
- Mount at Windrow Height

Spectrum Technologies
Artificial Humidification
Spraying Water on Windrow

- **Water Application**
  - CA: 40-50 Gal/A
  - AZ: 50 Gal/A
  - UT: 2-4 Gal/100’

- **Lag Time for Baling**
  - 5-30 Minutes
    - Moisture Penetration
    - Humidity & Wind
    - Time of Day
  - Manual Assessment

Windrow Structure

Short & wide during dry season
Tall & skinny during the wetter season
Artificial Humidification

- **Steam Injection**
  - Humidify Hay
- **Baling Period**
  - Flexible/Longer
  - Eliminates Balers
- **Improves Quality**
  - Reduce Leaf Loss
  - Higher RFV
- **Expensive**
Colorado River
Impact of Shortage Declaration

<table>
<thead>
<tr>
<th>Lake Mead Elevation</th>
<th>Arizona Reduction</th>
<th>Nevada Reduction</th>
<th>Mexico Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1075’</td>
<td>320,000 AF</td>
<td>13,000 AF</td>
<td>50,000 AF</td>
</tr>
<tr>
<td>1050’</td>
<td>400,000 AF</td>
<td>17,000 AF</td>
<td>70,000 AF</td>
</tr>
<tr>
<td>1025’</td>
<td>480,000 AF</td>
<td>20,000 AF</td>
<td>125,000 AF</td>
</tr>
</tbody>
</table>

- Greater use reductions at lower Mead elevations
- Arizona incurs ~80% of the reductions
- Negatively impacts Central Arizona agriculture
- Mexico reduction must be renewed in 2017
- Below 1025’ Secretary of Interior can intervene!
Water Year Precipitation
October through February

- Most locations above normal
- Upper Green 200-300% normal
- Mead drainage 130-200% normal
Reservoir Status
March 15 2017

All Arizona Reservoirs Increased Except Lake Powell
March 2017 Precipitation

Very dry except northern Utah and Wyoming
Snow Monitoring

Snow Pillows

Rain Gauge
Colorado Basin Snowpack

- Snowpack at 116% of normal, already 12% above seasonal peak
- Normal peak snowpack in early April
## Spring Flow Projections
### Colorado Basin

<table>
<thead>
<tr>
<th>River</th>
<th>March 1</th>
<th>March 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado</td>
<td>145%</td>
<td>138%</td>
</tr>
<tr>
<td>Gunnison</td>
<td>132%</td>
<td>116%</td>
</tr>
<tr>
<td>San Juan</td>
<td>120%</td>
<td>124%</td>
</tr>
<tr>
<td>Green</td>
<td>169%</td>
<td>160%</td>
</tr>
<tr>
<td>Gila</td>
<td>189%</td>
<td>182%</td>
</tr>
<tr>
<td>Salt</td>
<td>117%</td>
<td>108%</td>
</tr>
<tr>
<td>Verde</td>
<td>144%</td>
<td>134%</td>
</tr>
</tbody>
</table>

Dry March has reduced spring/summer flow projections.
2017 Colorado River Projections
Famine to Feast to ?

Colorado - Lake Powell- Glen Cyn Dam- AI (GLDA3)
2017-03-15 Apr-Jul Official 50% Forecast: 9900 kaf (138% of average)
ESP is Unregulated and No Precipitation Forecast Included

Max/Min
ESP 90%
ESP 50-70%
ESP 10-30%
Official

Mar 1, 2016
10.92 MAF

Current Forecast
8.87 MAF

Dec 14, 2016
4.72 MAF

The latest (2017-03-28) 50% ESP forecast is 8771 kaf.
Plot Created 2017-03-28 14:50:00, NOAA / NWS / GBRFC
Forecasts in the forecast target period include observed values.
## Lower Colorado River Over Allocation Problem

<table>
<thead>
<tr>
<th></th>
<th>Powell Release 8.23 maf</th>
<th>Powell Release 9.0 maf</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inflow</strong></td>
<td>+9.0 maf</td>
<td>+9.77 maf</td>
</tr>
<tr>
<td><strong>Outflow (AZ, CA, NV, MX+ Reg)</strong></td>
<td>-9.6 maf</td>
<td>-9.6 maf</td>
</tr>
<tr>
<td><strong>Evaporation</strong></td>
<td>-0.6 maf</td>
<td>-0.6 maf</td>
</tr>
<tr>
<td><strong>Balance</strong></td>
<td>-1.2 maf</td>
<td>-0.43 maf</td>
</tr>
<tr>
<td><strong>Elevation Loss</strong></td>
<td>~12’/year</td>
<td>~4.3’/year</td>
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Lake Mead levels will continue to decrease without a reduction in use or a series of wet winters that will allow for higher releases from Lake Powell.
Colorado River Shortage
Lake Mead Elevation Projections

If August projection for December 31, 2017 calls for Lake Mead level below 1075’ a shortage is to be declared. The current March forecast is well above 1075’ due to projection for lake equalization (release of extra water from Lake Powell).
Equalization is Just Projection
Decision Made in April

The operating tier for water year 2017, established in August 2016, is the Upper Elevation Balancing Tier, with an initial water year release volume of 8.23 maf and the potential for an April 2017 adjustment to equalization or balancing releases. Based on the March 1 forecast, an April adjustment to equalization releases is projected to occur and Lake Powell is currently projected to release 11.1 maf in water year 2017. This is only a projection, the actual April forecast and 24 Month Study will determine the final 2017 volume release from Glen Canyon Dam.
March Decline in Flow Forecast

It should be noted that since the March final forecast was issued on March 2, 2017, the Colorado Basin River Forecast Center Ensemble Streamflow Prediction indicates a decrease in the forecasted inflow. It is unlikely that the March final forecasted inflow will be sustained in the April final forecast. The April 24-Month Study projections are used to determine whether there is an adjustment to equalization or balancing under the Interim Guidelines governing Lake Powell releases for the remainder of water year 2017.
Hope This Comes True & In Time

Flow Projection w/o Precipitation: 8.87 MAF
Flow Projection with Precipitation: 9.47 MAF
Forecast: April-June 2017

--Weak to moderate warm bias in Arizona; no bias for precipitation
Forecast: July-September 2017

---Strong warm bias for AZ; no bias for monsoon precipitation
Return of El Niño???
Return of El Niño???

*ENSO-neutral is favored through mid-2017, with a slight tilt toward El Niño (~50%) during the late summer through fall 2017.*
Proposed New Drought Contingency Plan

Reductions in Colorado River Water Use

Lake Mead Elevation, Feet

- 1090-1075'
- 1075-1050'
- 1050-1045'
- 1045-1040'
- 1040-1035'
- 1035-1030'
- 1030-1025
- <1025

Acre-Feet

AZ Current  AZ Proposed  CA Proposed

0  100  200  300  400  500  600  700  800