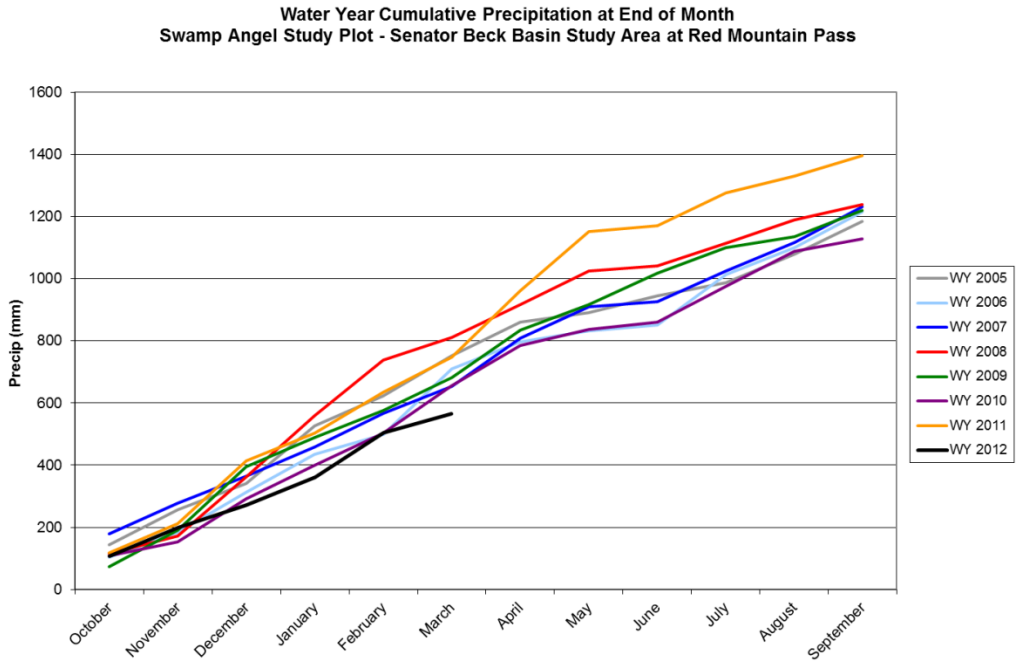
SUMMARY OF APRIL 4-11, 2012 CODOS CIRCUIT

The CSAS team's recent circuit of CODOS sites, and the valleys in between, has etched the remarkably snow-free landscape into memory, in contrast to still-vivid memories of Spring 2011. Locals throughout the state nervously compare this season with the spring of 2002, or even more extreme drought in earlier decades. Even though a return to winter weather is currently adding additional snow and restoring higher snow albedo to Colorado's mountain snowpack, the die for small and early runoff seems to be cast, and the probabilities of a late-spring recovery in snowpack water storage grow slimmer by the day, as more and more terrain becomes snow free.

In a synchronized display throughout the state, dust-on-snow has played a role, particularly in the past six weeks. However, the fundamental driver of the shortfall in snowmelt water supplies is the simple lack of snow precipitation. The Snotel network has documented this very dry winter throughout the Colorado mountain system and others, such as the State Climatologist, will no doubt evaluate the season's very warm air temperatures. Here at Senator Beck Basin, we've measured winter storms and Water Year precipitation since 2004 (see CSAS Storms and Precip Data Workbook) at our Swamp Angel Study Plot and Water Year 2012 is on track to be our driest winter to-date, as seen in the graph below. March 2012 was a particularly dry month here in the San Juan Mountains, and throughout the state, and April is also falling behind our own short period of record mean precipitation. That period of record, now into the 9th winter season, has established April as our wettest month, perhaps skewed by the relentless string of storms in April 2011.



Our Updates have discussed the severe shortfalls, statewide, in snowpack and SWE accumulation in March and early April, coincident with the deposition of several layers of Colorado Plateau (and even 'local') dust at the snowpack surface, also statewide, and the role of dust in warming and 'ripening' snowpacks to isothermal temperatures at/near 0° C. That process is largely elevation and aspect controlled, but vegetation and shading also play a major role. When the snowcover becomes isothermal, and the snowmelt energy budget is sustained and enhanced by reduced snow surface albedo in association with sunny weather, snowmelt discharge will commence and rapidly accelerate. That process began following dust event D4 in early March with the lowest elevation snowcover and has advanced to higher elevations beginning with sunny aspects and more slowly including more northerly terrain, as we've seen at Senator Beck Basin and throughout the state.

The very warm air temperatures recorded throughout March contributed to that process but, as our serendipitous observation of snowmelt processes shown in the images demonstrate, radiative forcing of the snowmelt energy budget can substantially outweigh the energy transfered to the snowpack by warm air. The first image (familiar to many of you from our CODOS presentations), taken on May 11, 2010 at our Swamp Angel Study Plot, illustrates the impact of albedo on snowmelt rates. In this case, a clean snowball of new snow (only) has rolled off a wooded slope onto a flatter meadow. That meadow had a considerable amount of dust at the snowpack surface prior to the inch or two of new snow. Within a day, radiation had penetrated through that thin layer of new snow and been absorbed into the dust, completely ablating the new snow in the meadow and continuing rapid melt of the underlying snowpack. Meanwhile, the very 'bright' white ball of new snow was reflecting the same radiative inputs, shielding the old snow underneath from that solar energy and leaving the snowball and old snow surface 'super elevated', relative to the rest of the meadow. Air temperatures around the snowball were no different than over the snow surface immediately adjacent to the snowball.

In the second case shown below, just observed during our approach to the Berthoud Summit Snotel and CODOS site on April 10th, the inverse effect of shading from radiative forcing is illustrated. Here, narrow shadows cast onto the snowpack by a metal gate and by a suspended chain have reduced direct radiative forcing of snowmelt over an extended period of time. Behind the sign, all of the snowpack has melted except the narrow fin of snow being shadowed by the gate. The fin is leaning toward the sun at the angle of incoming solar radiation (during early afternoon when trees adjoining this road are not also shading this location). Nearby, a chain suspended above the snow surface is producing a similar but reduced differential in melt rate since the shading is less complete. As was the case in the snowball example above, air temperatures can reasonably be assumed to be no different over the snowpack, from one side of these shadows to the other, during the evolution of these features.

These examples illustrate the challenge of interpreting radiative forcing effects on snowmelt rates using Snotel data, since many Snotel sites experience significant shading from adjoining trees.

Hydrographs throughout the Colorado mountains show the influence of the early onset of snowpack warming and subsequent snowmelt runoff. Although not high in absolute terms, most watersheds have experienced very high flows during March and early April, relative to normal (median) flows for a given date. Given that many Snotel sites may have recorded Peak SWE in early or mid-March (still subject to new major winter storms at some Snotels), as much as six weeks earlier than average, a substantial advance in overall snowmelt runoff timing, and in passage of center of mass, may be occurring.

Given the very extensive emergence of bare ground, at all elevations, and increasing plant activity, additional snowfalls that land on bare soil may be largely consumed by infiltration and evapotranspiration, and not reach water courses – we observed green grass at the base of and near many snowpits, and tree leafing in many locales during our circuit. At this time, it seems that only alpine terrain retaining significant snowcover would capture and store, albeit briefly, any additional SWE from winter storms. New snow falling on bare ground in alpine terrain will quickly melt.

UPDATES BY SITE:

Berthoud Summit (April 10) | Grand Mesa (Apr 4) | Grizzly Peak (April 10) | Hoosier Pass (April 9)
McClure Pass (April 11) | Park Cone (April 9) | Rabbit Ears Pass (April 10) | Senator Beck Basin (Apr 7-8)
Spring Creek Pass (April 9) | Willow Creek Pass (April 10) | Wolf Creek Pass (April 9)

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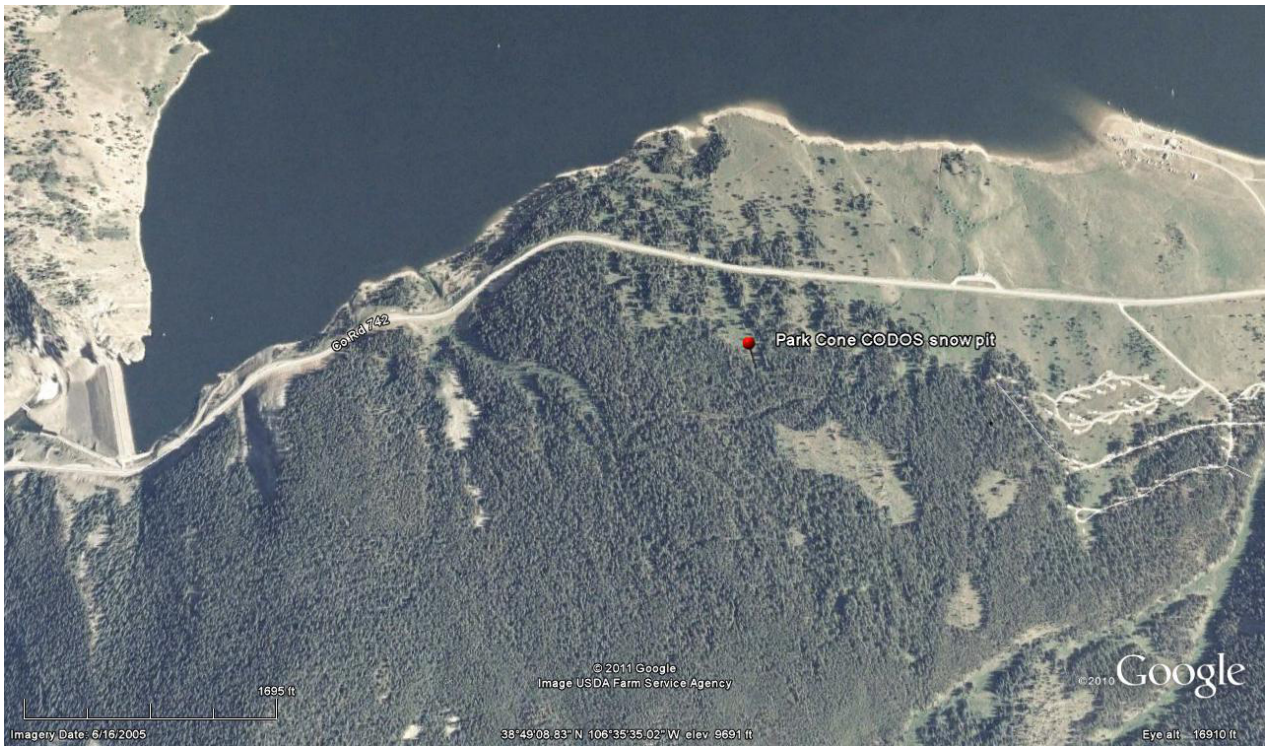
CODOS UPDATE FOR BERTHOUD SUMMIT: VISITED APRIL 10, 2012

Summary | Snowpack | Melt Rate | Forecast | Stream Flows | Earlier Updates



SUMMARY

Sustained periods of unseasonably warm air temperatures and exposed dust at the snowpack surface during late March and early April 2012 have, together, initiated accelerating rates of snowmelt and SWE loss at some, but not all, CODOS Snotel sites. Some CODOS Snotel sites report significant declines in SWE approaching the lowest values in the period of record (for a given date) or even falling outside of the historic range. Those sites *may* have experienced Peak SWE for WY 2012 in early or mid-March. Recent CODOS snowpits near those CODOS sites mirror those losses of SWE.

In contrast, other CODOS Snotel sites and CODOS snowpits show only small losses of SWE. At those sites, energy inputs from warm air and direct absorption of solar energy by dust at the snowpack surface was consumed in warming the snowpack towards an isothermal state at 0° C, as a precursor to the loss of SWE and onset of snowmelt runoff. Since our prior site visit on March 14 the snowpack at the Berthoud Summit CODOS site has lost all cold content and is now isothermal.

The National Weather Service expects warming weather in the Colorado mountains through Wednesday with strong SW'ly winds developing on Wednesday afternoon ahead of a cooler but largely dry air mass. Unsettled and cooler weather will finish the week and run through the weekend, including chances for rain and/or snow showers each day.

SNOWPACK DISCUSSION

The snowcover at the Berthoud Summit CODOS site has undergone complete warming to 0°C throughout since our March 15 snowpit and is beginning to more rapidly melt. We walked to this site on dry ground for much of the approach. Dust loading at the Berthoud Summit site is similar to that observed at Grizzly Peak - more intense than at Hoosier Pass, but still less intense than at our Senator Beck Basin study sites. Reduction in snow surface albedo has been sufficient to absorb additional solar energy at the snowpack surface and contribute to warming and ablation of the snowcover. As previously discussed, the Berthoud Summit SNOTEL site is in an open meadow, unshaded by the adjoining forest. As a consequence, SNOTEL snowmelt rate and snowpack depth data fully capture the influence of direct radiative forcing when snow albedo is lowered by dust, in contrast to other, shaded SNOTEL sites. Our CODOS snowpit site is located immediately in front of the SNOTEL station, in the same open meadow.

On March 15th the snowpack at our Berthoud Summit CODOS snowpit site was 44" (112 cm) deep and most of the snowpack consisted of very weak "depth hoar" grains; mean snowpack temperature was -2.6°C. Dust event D4 was clearly evident on the snow surface at the snowpit and in terrain around Berthoud Pass. SWE content in the snowpit was 13.2" (336 mm) and mean density of the snowpack was 308 kg/m^3 (30.8% water content). As a result of the subsequent, prolonged period of warm, dry, and sunny weather, and some additional small reductions in snow albedo from additional dust events, the snowpack on April 10th was fully isothermal (0°C), with wet or very wet snow throughout. Total SWE in this pit was 8.7" (220 mm), a loss of 4.6" (116 mm) since March 15th; total snow depth was down to 20.5" (52 cm) and density had risen to 393 kg/m^3 (39.3% water content).

April 10, 2012:

Pit profile

Completed pit

Pit with SNOTEL in background

March 15, 2012:

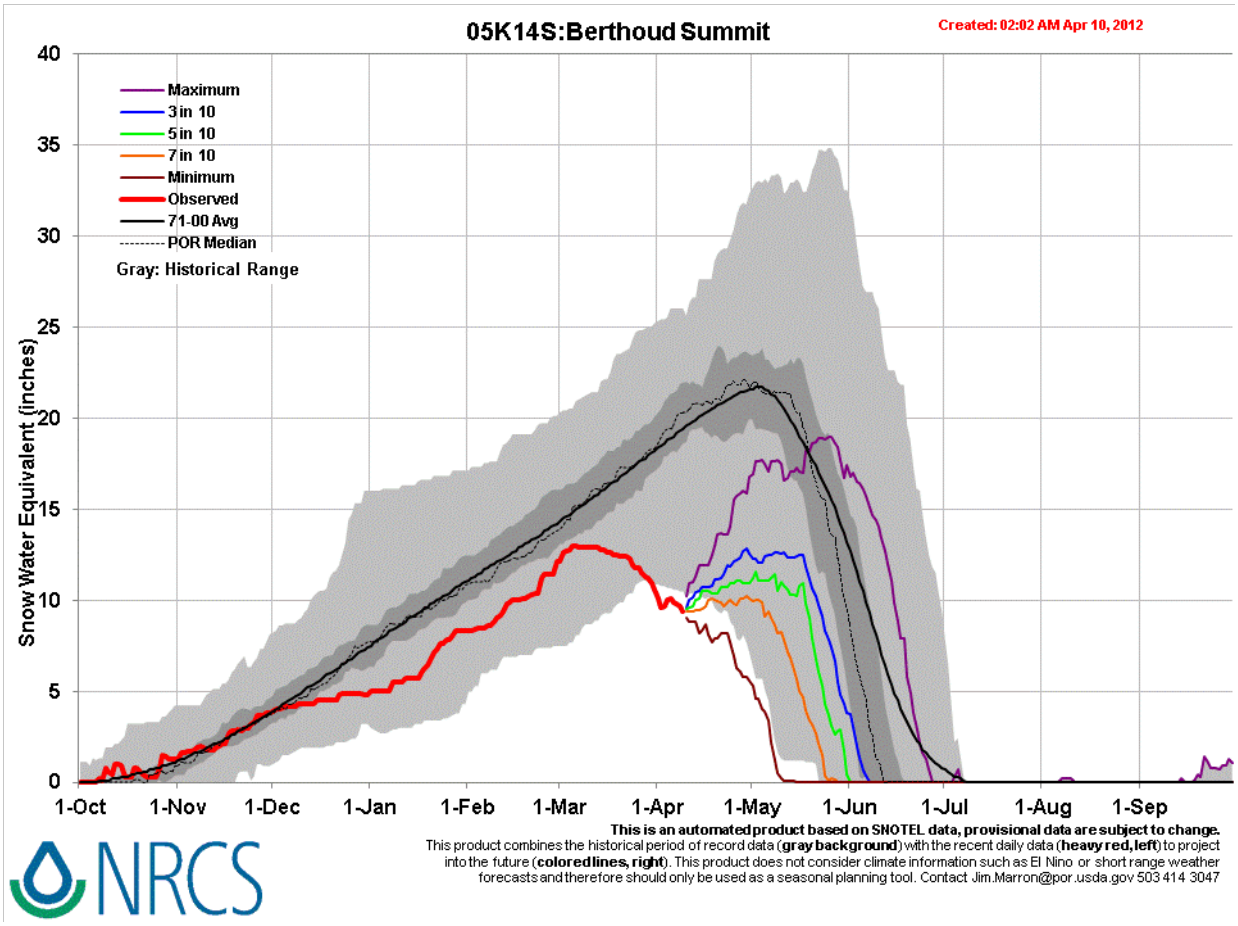
MELT RATE

Berthoud Summit Snotel has reported a loss of 3.8" of SWE since our last site visit on March 15, 2012, not long after what may have been Peak SWE for WY 2012. This melt rate falls well short of the mean daily loss of SWE at Berthoud Summit observed in prior snowmelt seasons, as shown in the table below. However, even at current melt rates, SWE values may remain below the lowest quartile for the duration of WY 2012.

Berthoud Summit SNOTEL Snowmelt Season Summary Data

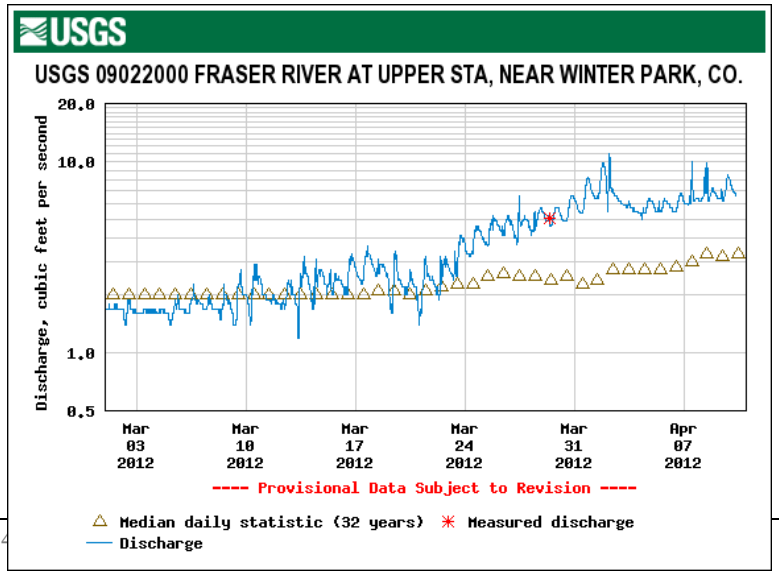
	Date Peak SWE	Peak SWE	Days to SAG	Post-Peak Added SWE	Adjusted Daily Mean Loss SWE	Period Mean Temp
WY 2006	4/21/2006	24.0	41	3.8	0.68	3.5
WY 2007	4/27/2007	22.2	46	4.5	0.58	4.4
WY 2008	5/16/2008	24.4	34	1.4	0.76	5.8
WY 2009	4/20/2009	24.7	50	5.2	0.60	4.0
WY 2010	5/16/2010	24.5	23	0.6	1.09	6.6
WY 2011	5/26/2011	34.8	35	2.0	1.05	8.4
Max	5/26	34.8	50	5.2	1.09	8.4
Min	4/20	22.2	23	0.6	0.58	3.5
Range	37	12.6	27	4.6	0.51	4.9

Adjusted Daily Mean Loss SWE rates include additional SWE received after date of Peak SWE



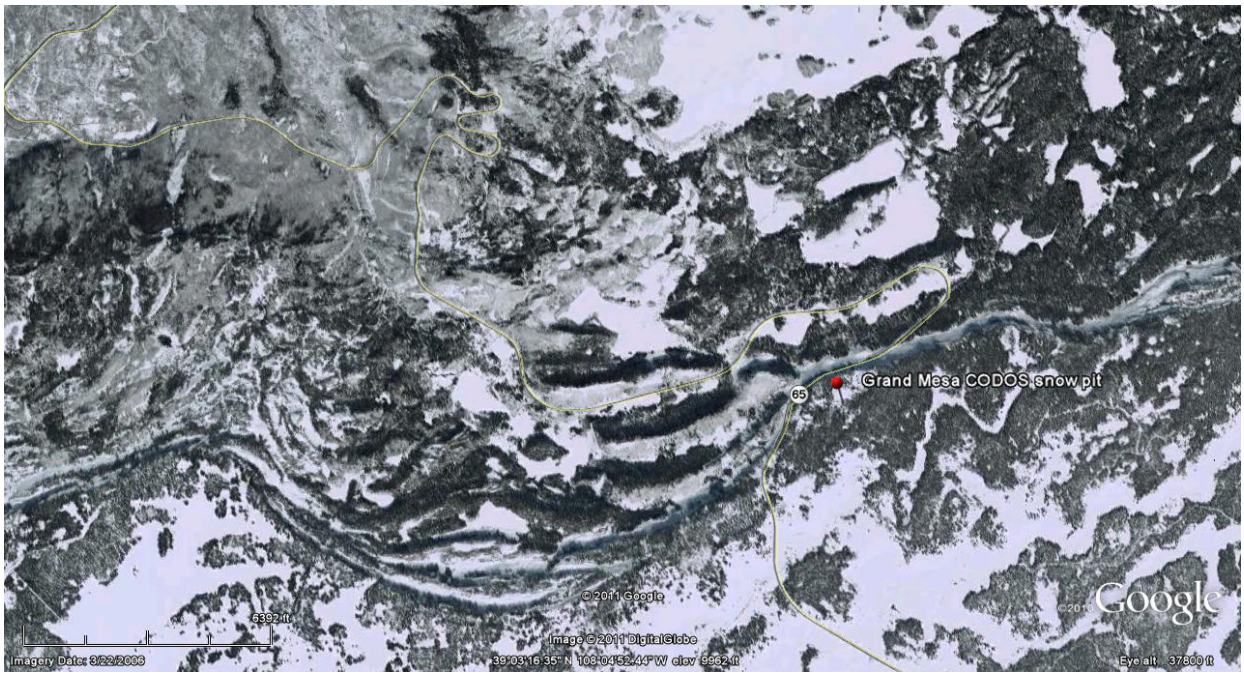
STREAM FLOWS

Stream flow behavior at the USGS Fraser River Upper Staion near Winter Park gauge reports a brief decline in discharge in early April, after a significant surge in late March. Flows in late March were high, compared to median levels at that gauge, for that period. Unsettled weather in early April ushered in cooler air and cloudier skies for the following several days. Interestingly, flows stabilized during that period at more than double the median values.



CODOS UPDATE FOR GRAND MESA:
VISITED APRIL 4, 2012

Summary | Snowpack | Melt Rate | Stream Flows | Forecast | Previous Update | pdf



SUMMARY

As of this writing on April 5, 2012, warm air temperatures and reductions in snow albedo caused by merged dust layers D6/D5/D4 have, together, initiated accelerating rates of snowmelt and SWE loss at some, but not all, CODOS Snotel sites. Between March 26 and April 2 the Swamp Angel Study Plot at Senator Beck Basin lost 4.6" SWE (117 mm) and 14" (35 cm) in snowpack depth. Some CODOS Snotel sites report significant declines in SWE to levels approaching the lowest values in the period of record (for a given date) or even falling outside of the historic range. Those sites *may* have, then, already experienced Peak SWE for WY 2012.

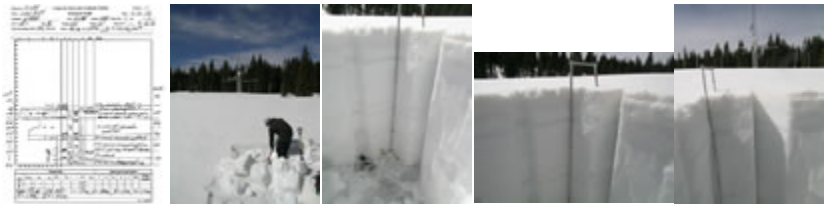
In contrast, even with reductions in snow albedo comparable to those at Swamp Angel Study Plot, between March 16 and April 4 our Grand Mesa Study Plot lost almost no SWE (0.15") even while the snowpack lost 9" in depth. The nearby Mesa Lakes Snotel also recorded virtually no net loss of SWE since our March 16 site visit, while losing 10" of depth. At Grand Mesa, and other locales exhibiting this static SWE, another significant storm in coming days could produce this season's Peak SWE value at/near the normal date for Peak SWE, albeit at well below average levels. At those sites where snowmelt has been slow to accelerate, solar energy absorbed by dust at the snowpack surface, and transmitted into the snowpack as melt energy contained in percolating free water, may have been consumed in warming the snowpack to 0° C throughout (isothermal). Event D7, and the potential for additional dry dust

deposition later today (April 5), will further enhance direct absorption of radiation during the generally dry and warm weather expected to continue through April 10-12.

SNOWPACK DISCUSSION

Our snow profile on April 4 found virtually no net loss of SWE since the March 16 profile, but did show settlement and densification of the snowpack. This evolution is replicated in the Mesa Lakes Snotel data for the period, also showing very little loss in SWE but considerable loss of snowpack depth. Aside from the temporarily re-frozen, laminated ice layers in the top 10 inches, the April 4 profile presented wetter snow than was observed in the March 16 profile, and snow temperatures within the April 4 snowpit were fully isothermal (aside from the refrozen near surface snow, which was likely to fully thaw later that day). A small amount of cold content was measured in the snowpack in our March 16 snowpit.

The April 1st dust layer D7 was very evident on the Grand Mesa during our April 4 site visit, captured within and sitting underneath an inch or two of new snow that fell with the dust. That dust fell onto the merged D6/D5/D4 dust at the snowpack surface. During our visit, the new snow above and containing D7 dust (photo) was visibly melting and merging with that underlying dust.



MELT RATE

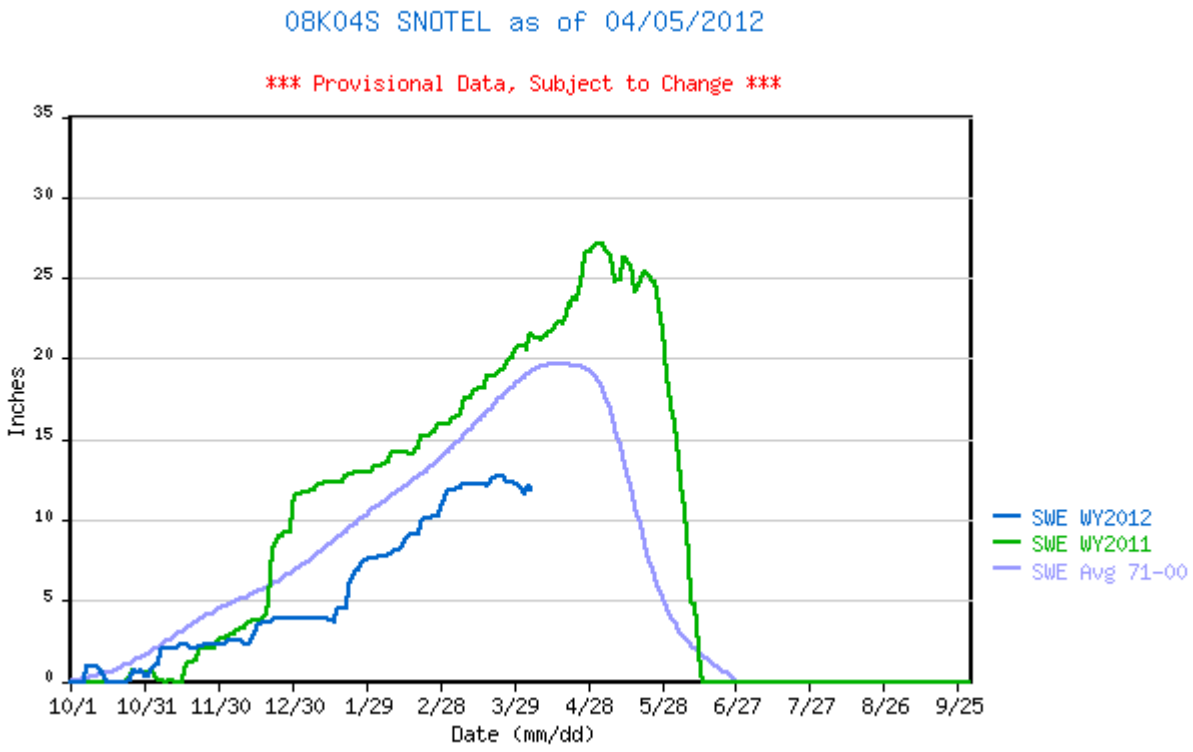
Despite reduced snow albedo values often in the 60% range (dust-free spring snow values can be near 80%), and warm temperatures, almost no net loss of SWE was reported at the Mesa Lakes Snotel in the past three weeks. Very small losses in SWE during that period were offset by a gain of about 0.5" SWE on March 18/19 during the storm that delivered D5. SWE measured in our snow profiles at our Grand Mesa Study Plot also showed virtually no net loss, at 20.0" (509 mm) on March 16 compared to 19.85" (504 mm) on April 4. Apparently, melt energy produced by dust-enhanced melt at the snowpack surface during this period was largely consumed, at these elevations, in finally warming the snowpack to 0° C (isothermal) throughout. Observation of lower elevation snowcover extent on the flanks of Grand Mesa do, however, reveal substantial loss of snowpack there, as reflected in recent streamflow data.

As a result of this static level in SWE, it remains possible for this season's Peak SWE to still occur at the Mesa Lakes Snotel site at or near the 30-year average date, given a significant storm.

Mesa Lakes SNOTEL Snowmelt Season Summary Data

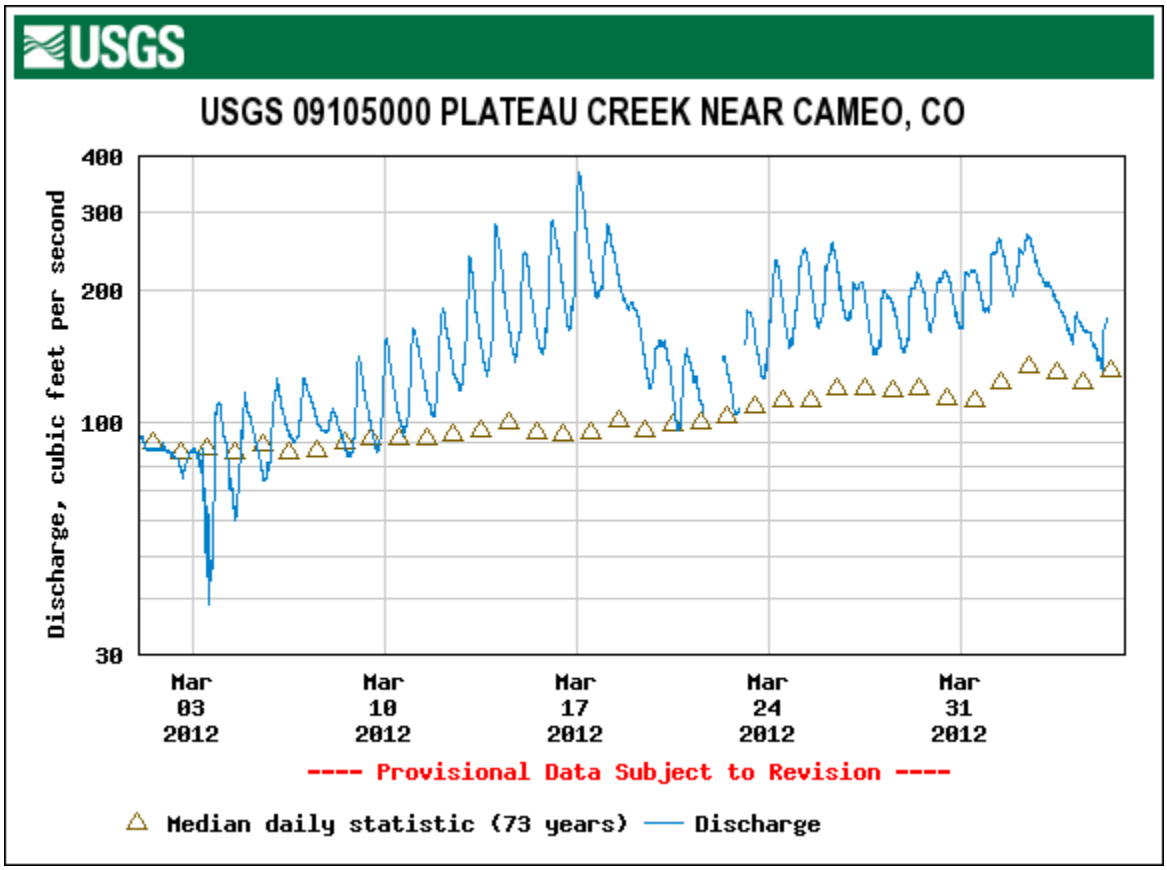
	Date Peak SWE	Peak SWE	Days to SAG	Post-Peak Added SWE	Adjusted Daily Mean Loss SWE	Period Mean Temp
WY 2006	4/8/2006	17.9	39	1.6	0.50	3.8
WY 2007	4/14/2007	13.0	31	3.1	0.52	3.3
WY 2008	4/12/2008	23.3	59	5.3	0.48	3.1
WY 2009	4/18/2009	19.2	32	2.5	0.68	5.0
WY 2010	4/9/2010	16.9	51	5.0	0.43	2.9
WY 2011	5/4/2011	27.1	41	4.0	0.76	5.8
Max	5/4	27.1	59	5.3	0.76	5.8
Min	4/8	13.0	31	1.6	0.43	2.9
Range	27	14.1	28	3.7	0.33	2.9

Adjusted Daily Mean Loss SWE rates include additional SWE received after date of Peak SWE



STREAM FLOWS

Increased flows on Plateau Creek following the decline during and just after the March 18/19 snowfall include the influence of D5 and D6 reductions in albedo, and of the very warm weather, particularly on the lowest elevation snowcover. The minor snowfall that delivered D7 and a cool-down on April 1 produced another decline in runoff rates, and the incremental reduction in albedo produced by D7 was underway during our site visit on April 4, and will begin to be reflected in streamflow today, April 5, as that layer becomes fully emergent (and merges with D6/D5/D4) and temperatures rebound.



FORECAST

Strong SW'ly winds in southeast and eastern Utah, northeastern Arizona, and western Colorado, pose a risk for another dry dust storm today and tonight, April 5, with very low chances of accompanying snowfall but with some cooling in air temperatures Friday. Beginning Saturday high pressure will rebuild over western Colorado bringing dry and warmer weather through mid-week, although some models present a small chance of Gulf of Mexico moisture reaching the San Juan Mountains Tuesday through Thursday (April 10-12).

CODOS UPDATE FOR GRIZZLY PEAK:
VISITED APRIL 10, 2012

Summary | Snowpack | Melt Rate | Forecast | Stream Flows | Earlier Updates

SUMMARY

Sustained periods of unseasonably warm air temperatures and exposed dust at the snowpack surface during late March and early April 2012 have, together, initiated accelerating rates of snowmelt and SWE loss at some, but not all, CODOS Snotel sites. Some CODOS Snotel sites report significant declines in SWE approaching the lowest values in the period of record (for a given date) or even falling outside of the historic range. Those sites *may* have experienced Peak SWE for WY 2012 in early or mid-March. Recent CODOS snowpits near those CODOS sites mirror those losses of SWE.

In contrast, other CODOS Snotel sites and CODOS snowpits show only small losses of SWE. At those sites, energy inputs from warm air and direct absorption of solar energy by dust at the snowpack surface was consumed in warming the snowpack towards an isothermal state at 0° C, as a precursor to the loss of SWE and onset of snowmelt runoff. Since our prior site visit on March 15 the snowpack at the Grizzly Peak CODOS site has lost all cold content and is now isothermal.

The National Weather Service expects warming weather in the Colorado mountains through Wednesday with strong SW'ly winds developing on Wednesday afternoon ahead of a cooler but largely dry airmass. Unsettled and cooler

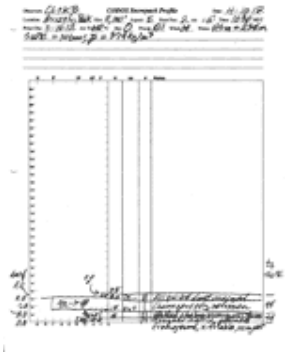
weather will finish the week and run through the weekend, including chances for rain and/or snow showers each day.

SNOWPACK DISCUSSION

The snowcover at the Grizzly Peak Pass CODOS site has undergone complete warming to 0°C thoughout since our March 15 snowpit and is rapidly melting. We walked to this site on dry ground for much of the approach. Dust loading at Grizzly Peak Pass is more intense than at Hoosier Pass, but still less intense than at our Senator Beck Basin study sites. Reduction in snow surface albedo has been sufficient to absorb additional solar energy at the snowpack surface and contribute to warming and ablation of the snowcover. Again, as noted in prior discussions, considerable open ground may be contributing 'local' dust and vegetation debris to the snowpack in these Front Range locales, compounding the effects on albedo produced by Colorado Plateau dust.

On March 15th the snowpack at our Grizzly Peak CODOS snowpit site was 41" (104 cm) deep and most of the snowpack consisted of very weak "depth hoar" grains; mean snowpack temperature was -4.6 C. Dust event D4 was clearly evident on the snow surface at the snowpit and in terrain around Loveland Pass. SWE content in the snowpit was 12.2" (311 mm) and mean density of the snowpack was 290 kg/m^3 (29.0% water content). As a result of the subsequent, prolonged period of warm, dry, and sunny weather, and some additional small reductions in snow albedo from additional dust events, the snowpack on April 10th was fully isothermal (0°C), with wet or very wet snow throughout. Total SWE in this pit was only 5.7" (144 mm), a loss of 6.6" (167 mm) since March 15th; total snow depth was down to 14" (35 cm) and density had risen to 379 kg/m^3 (37.9% water content).

April 10, 2012:



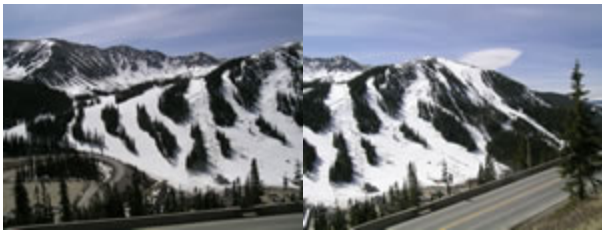
Pit profile

Grizzly Peak Snotel

Pit with A-Basin in Background

Completed pit

Patchy ground near pit site



A-Basin from road above pit area

March 15, 2012:

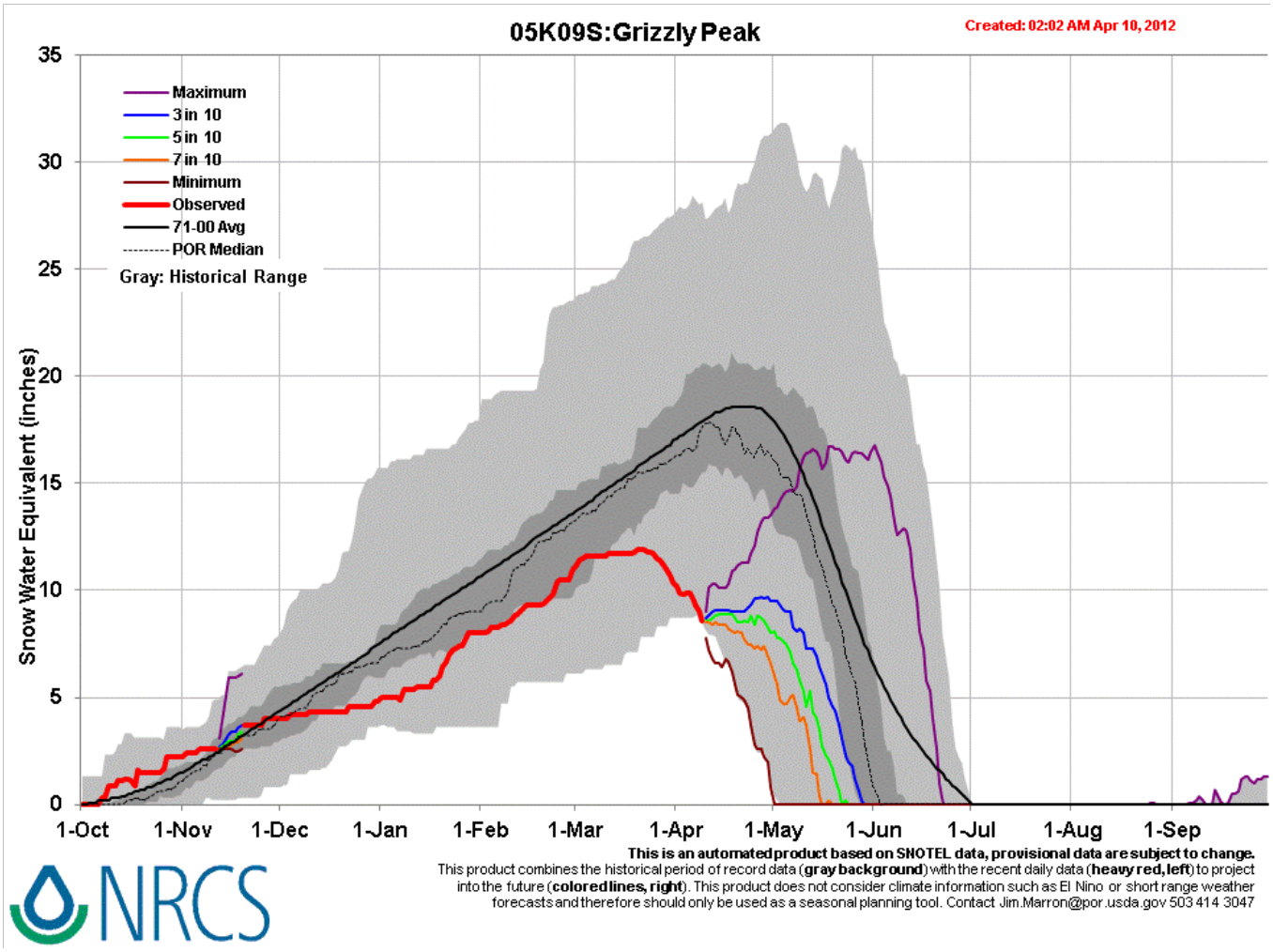
MELT RATE

Grizzly Peak SNOTEL has reported a loss of almost 4"of SWE since our last site visit on March 15, 2012. Recent data shows melt rates approaching the 2010 mean daily SWE loss rate. As discussed above, at a loss of 6.6" of SWE, melt rates in the open meadow where we dig our CODOS snowpits. This differential between a tree-shaded SNOTEL site and a nearby open meadow is typical. If melt rates at the Grizzly Peak SNOTEL continue their recent acceleration, SWE values may fall below the lowest quartile inthe period of record.

Grizzly Peak SNOTEL Snowmelt Season Summary Data

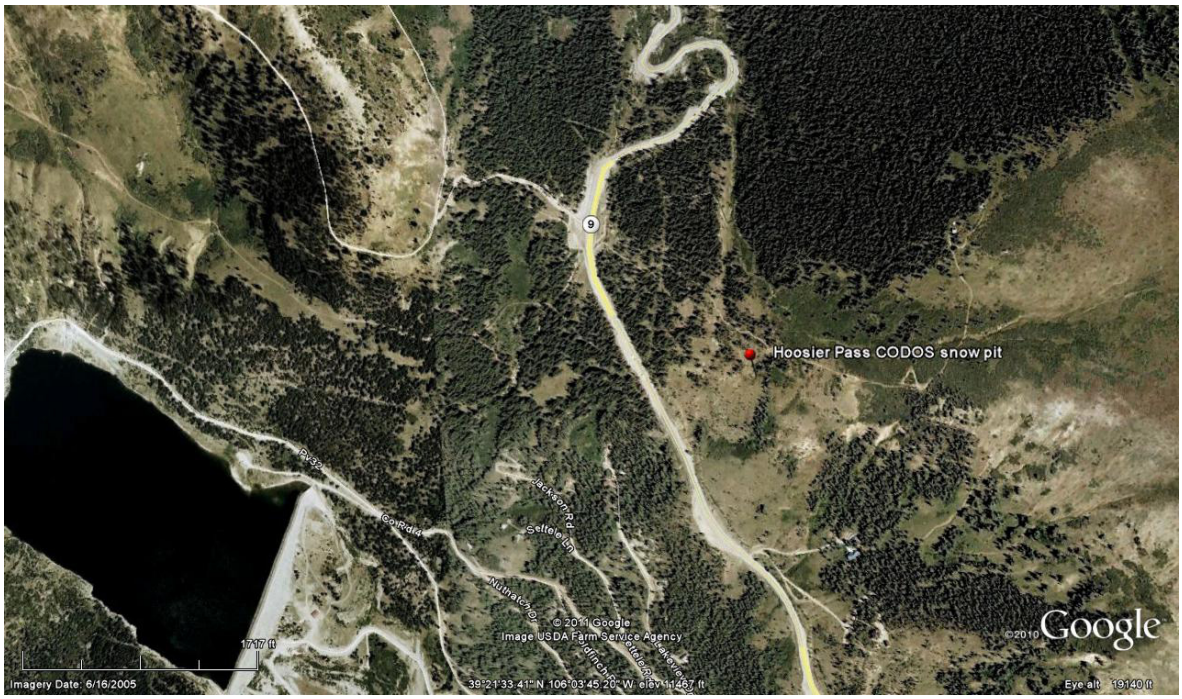
	Date Peak SWE	Peak SWE	Days to SAG	Post-Peak Added SWE	Adjusted Daily Mean Loss SWE	Period Mean Temp
WY 2006	4/4/2006	21.6	49	3.5	0.51	2.3
WY 2007	4/20/2007	20.6	43	3.0	0.55	3.0
WY 2008	4/13/2008	23.0	56	4.8	0.50	1.7
WY 2009	4/20/2009	21.6	47	5.2	0.57	3.7
WY 2010	4/9/2010	12.8	50	6.0	0.38	1.3
WY 2011	5/5/2011	31.8	52	5.8	0.72	5.1
Max	5/5	31.8	56	6.0	0.72	5.1
Min	4/4	12.8	43	3.0	0.38	1.3
Range	32	19.0	13	3.0	0.35	3.9

Adjusted Daily Mean Loss SWE rates include additional SWE received after date of Peak SWE



CODOS UPDATE FOR HOOSIER PASS: VISITED APRIL 9, 2012

Summary | Snowpack | Melt Rate | Stream Flows | Previous Update



SUMMARY

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The National Weather Service expects warming weather in the Colorado mountains through Wednesday with strong SW'ly winds developing on Wednesday afternoon ahead of a cooler but largely dry airmass. Unsettled and cooler weather will finish the week and run through the weekend, including chances for rain and/or snow showers each day.

SNOWPACK DISCUSSION

The snowcover at the Hoosier Pass CODOS site has undergone complete warming since our March 14 snowpit and is rapidly melting, exposing large patches of open ground between patches of remaining snowcover in this thinly wooded area near treeline. We walked to this site on dry ground for much of the approach. Dust loading at Hoosier Pass is much less intense than at our Senator Beck Basin study sites but has been sufficient to absorb additional solar energy at the snowpack surface and contribute to warming and ablation of the snowcover. Again, as noted in prior discussions, considerable open ground may be contributing 'local' dust and vegetation debris to the snowpack in these Front Range locales, compounding the effects on albedo produced by Colorado Plateau dust.

On March 14th the snowpack at our Hoosier Pass CODOS snowpit site was 41" (105 cm) deep and most of the snowpack consisted of very weak "depth hoar" grains; mean snowpack temperature was -3.7 C. Dust event D4 was clearly evident on the snow surface at the snowpit and in terrain around Hoosier Pass. SWE content in the snowpit was 11.1" (281 mm) and mean density of the snowpack was 273 kg/m3 (27.3% water content). As a result of the subsequent, prolonged period of warm, dry, and sunny weather, and some additional small reductions in snow albedo from additional dust events, the snowpack on April 9th was fully isothermal (0°C), with wet or very wet snow throughout. Total SWE in this pit was actually higher than in the March 14 pit, at 13.2" (336 mm), likely due to wind-related spatial variation in snowpack and perhaps contribution of melt water from uphill snowcover; total snow depth was down to 32" (81 cm) and density had risen to 410 kg/m3 (41.0%).

In general, snowcover in the Hoosier Pass vicinity is extremely sparse.

April 9, 2012:

Pit profile

Hoosier Snotel

Looking downhill from pit

Looking uphill from pit site

April 9th pit

Patchy area surrounding pit

March 14, 2012:



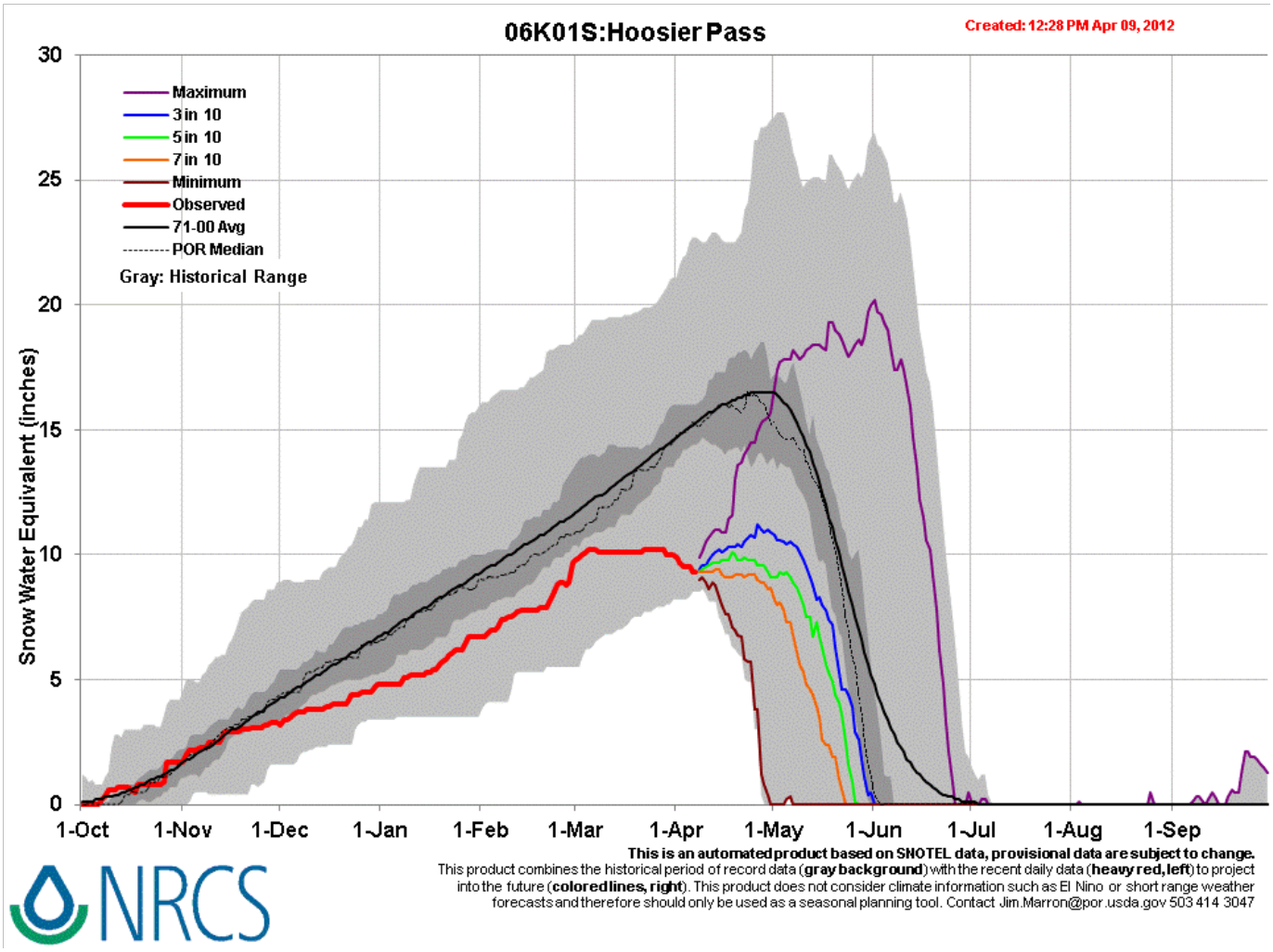

MELT RATE

The Hoosier Pass Snotel site, which is shaded by adjoining trees, has shown very small losses of SWE since mid-March and retains about 9" of SWE. These melt rates fall well short of those observed in prior years.

Hoosier Pass SNOTEL Snowmelt Season Summary Data

	Date Peak SWE	Peak SWE	Days to SAG	Post-Peak Added SWE	Adjusted Daily Mean Loss SWE	Period Mean Temp
WY 2006	4/9/2006	19.3	49	2.7	0.45	3.5
WY 2007	4/28/2007	18.5	45	3.2	0.48	4.2
WY 2008	4/15/2008	20.8	61	4.2	0.41	2.5
WY 2009	4/20/2009	17.3	47	5.3	0.48	3.8
WY 2010	5/4/2010	14.7	31	1.8	0.53	3.3
WY 2011	5/5/2011	21.9	44	3.1	0.57	4.2
Max	5/5	21.9	61	5.3	0.57	4.2
Min	4/9	14.7	31	1.8	0.41	2.5
Range	27	7.2	30	3.5	0.16	1.7

Adjusted Daily Mean Loss SWE rates include additional SWE received after date of Peak SWE



STREAM FLOWS

We cannot interpret currently posted streamflow data for Blue River, the South Fork of the South Platte in South Park, or for Tarryall Creek at Como.

CODOS UPDATE FOR MCCLURE PASS:
VISITED APRIL 11, 2012

Summary | Snowpack | Melt Rate | Stream Flows | Previous Update

SUMMARY

Sustained periods of unseasonably warm air temperatures and exposed dust at the snowpack surface during late March and early April 2012 have, together, initiated accelerating rates of snowmelt and SWE loss at some, but not all, CODOS Snotel sites. Some CODOS Snotel sites report significant declines in SWE approaching the lowest values in the period of record (for a given date) or even falling outside of the historic range. Those sites *may* have experienced Peak SWE for WY 2012 in early or mid-March. Recent CODOS snowpits near those CODOS sites mirror those losses of SWE.

In contrast, other CODOS Snotel sites and CODOS snowpits show only small losses of SWE. At those sites, energy inputs from warm air and direct absorption of solar energy by dust at the snowpack surface was consumed in warming the snowpack towards an isothermal state at 0° C, as a precursor to the loss of SWE and onset of snowmelt runoff. As of our site visit on April 11, and since our prior site visit on March 16, snowcover has disappeared from the McClure Pass CODOS site, and the nearby Snotel has lost snowcover over a portion of the pillow.

Strong SW'ly winds and showers developed on Wednesday afternoon ahead of a cooler airmass bringing unsettled and cooler weather for the remainder of this week, with chances for snow showers each day and temperatures below seasonal norms. Chances increase for more significant snow amounts over the weekend and may result in state-wide restoration of higher snow albedo. Showers may continue into the early work week but high pressure is expected to return to the State by mid-week with dry and warmer weather.

SNOWPACK DISCUSSION

Snowcover has completely disappeared from the CODOS McClure Pass snowpit site, located in an open meadow adjoining the McClure Pass Snotel site, itself in an aspen grove. As of our site visit on April 11th, virtually the only snow in this immediate vicinity was within the Snotel site itself, which was reporting 6" of snow containing 3.5" of SWE at the time of our visit. Even then, the snowcover has melted off of the southern edge of the snow pillow, as seen in the photo below, and this Snotel site will report "snow all gone" in a day or two, absent a significant winter storm. Snowcover in the higher alpine terrain of the upper Crystal River valley appeared, from a long distance, to present reduced albedo comparable to that observed on Grand Mesa – less reduction than observed in Senator Beck Basin, but more than observed at the dustier Front Range sites.

April 11, 2012:

McClure Snotel

McClure CODOS pit site with 'Snow All Gone

Snotel SWE pillow

Near McClure Pass

Muddy Creek Reservoir

March 16, 2012:

Pit profile from March 16

Digging March 16 pit

Near McClure Pass

MELT RATE

Peak SWE of 12.7" occurred a few weeks earlier than normal at the McClure Pass Snotel, on March 20th, as a result of the snowfall that delivered dust layer D5. That storm was the last significant snowfall at this site and, barring a major winter storm in the next few days, snow all gone (SAG) is imminent or has already occurred (no valid SWE data and only 1" of snow depth reported on the morning of April 12). Since early April, SWE values have fallen below the lowest values reported in the period of record at this Snotel. Since Peak SWE melt rates have averaged 0.42" per day but reached rates as high as 1.0" per day in recent days. Rain on the afternoon of April 11 may have hastened the ablation of the very wet snow remaining on the snow pillow. However, as at other CODOS sites, even though the McClure Pass Snotel site is only weakly shaded by aspen trees, the melt rates in the open meadow where CODOS snowpits are dug were higher and the snowpit plot reached SAG earlier than the Snotel site, by some unknown number of days prior to our visit on April 11th.

Melt rates at the higher elevation **Schofield Pass Snotel** in the Crystal River headwaters (see snowmelt analysis table and SNOTEL graph) have been slower (but no SWE data has been reported since April 8th), since the snowpack at that elevation may have only recently become isothermal or remains just short of isothermal.

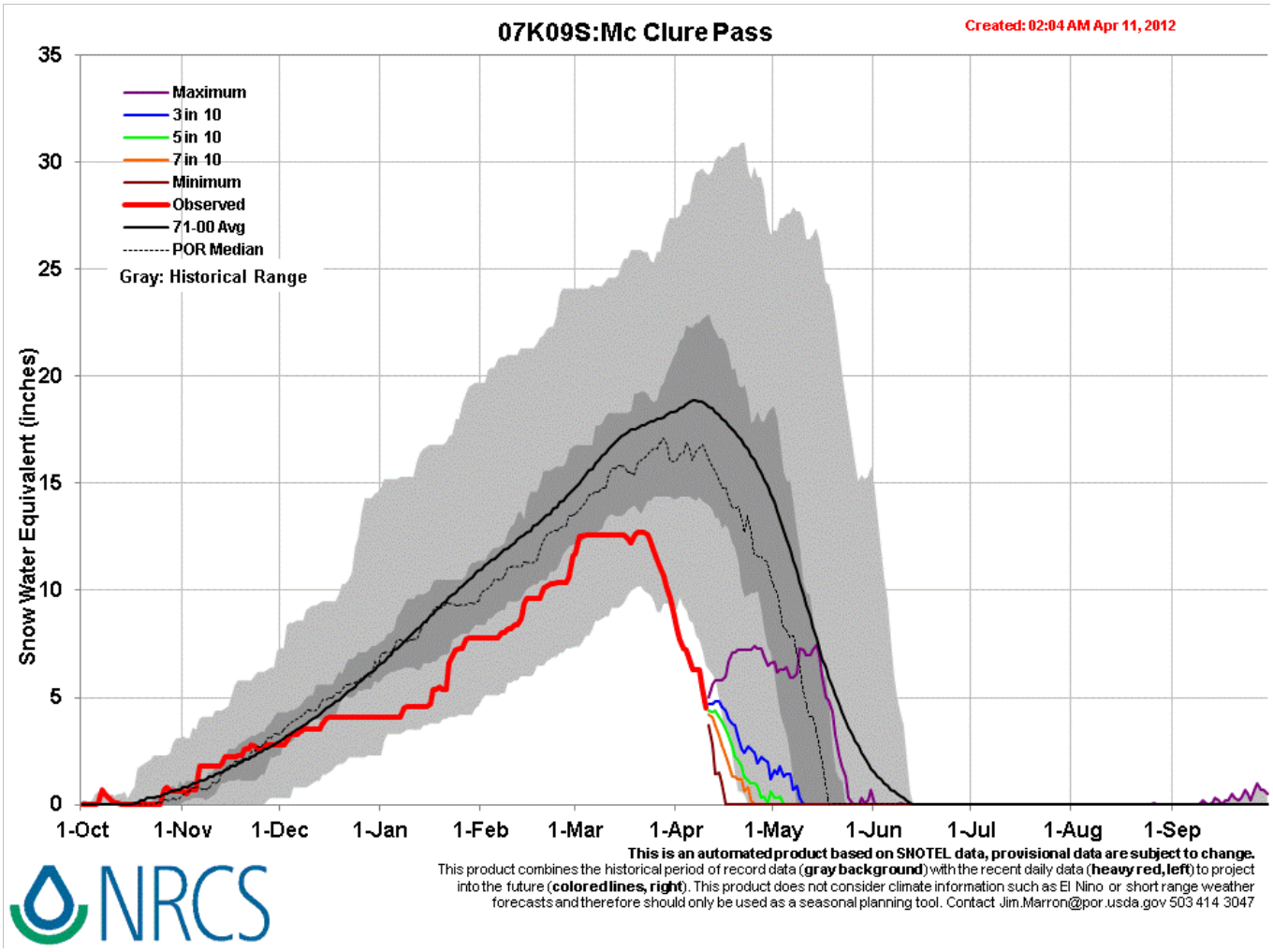
Farther east, at the headwaters of the Roaring Fork River, the **Independence Pass Snotel** (see snowmelt analysis table and SNOTEL graph) has reported substantial snowmelt since mid-march, losing more than 2.5" of SWE since peaking at just 9.9" on March 19th during the storm that delivered dust event D5. Average date of Peak SWE is April 11th. Although no valid SWE data have been posted since April 9th, prior recent data fall well below the lowest values for the period of record at this site. Observers in the Aspen area verified most/all dust events logged at Senator Beck Basin, although the intensity of those events in the Aspen area, relative to Senator Beck Basin, is not known.

Finally in the Eagle River headwaters, the **Vail Mountain Snotel** (see SNOTEL graph) is already reporting SAG, well ahead of the average date of Peak SWE. Peak SWE of only 11.3" occurred in early March and was entirely ablated by early April (data currently show negative SWE values).

McClure Pass SNOTEL Snowmelt Season Summary Data

	Date Peak SWE	Peak SWE	Days to SAG	Post-Peak Added SWE	Adjusted Daily Mean Loss SWE	Period Mean Temp
WY 2006	4/8/2006	20.5	30	1.5	0.73	6.6
WY 2007	3/13/2007	15.5	56	5.9	0.38	4.7
WY 2008	4/16/2008	29.3	40	2.3	0.79	5.5
WY 2009	4/8/2009	24.2	30	2.4	0.89	5.5
WY 2010	4/10/2010	20.3	38	3.0	0.61	5.0
WY 2011	3/31/2011	22.8	62	9.0	0.51	4.5
Max	4/16	29.3	62	9.0	0.89	6.6
Min	3/31	15.5	30	1.5	0.38	4.5
Range	17	13.8	32	7.5	0.50	2.0

Adjusted Daily Mean Loss SWE rates include additional SWE received after date of Peak SWE

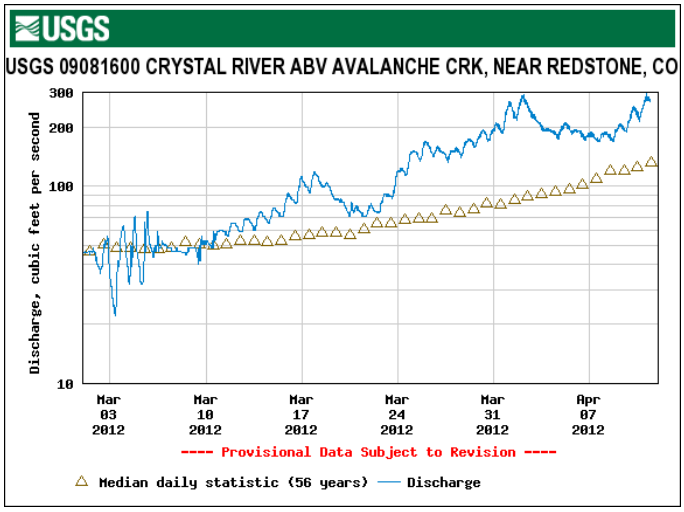


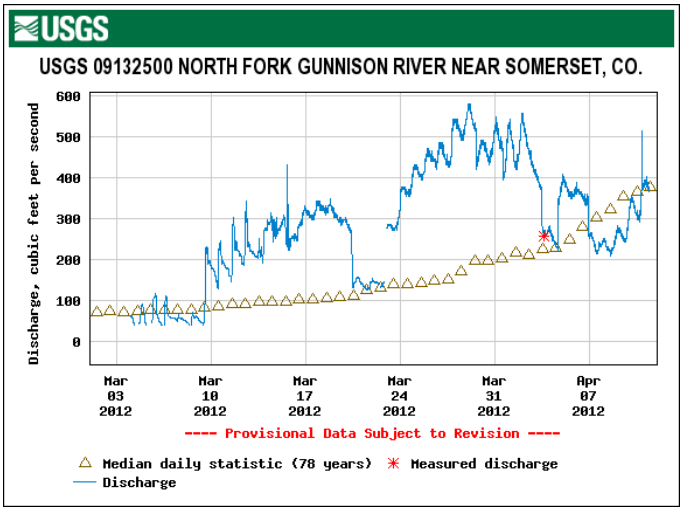
STREAM FLOWS

The following hydrographs of Muddy Creek, the Crystal River, and the North Fork of the Gunnison show very similar patterns of surge and retreat in recent weeks. Following a decline in flows after the mid-March storm delivering dust layer D5, significant surging in late March produced high flows at all three gauges, compared to median levels for that period. Unsettled weather in early April brought cooler temperatures, small amounts of new snow that briefly increased snow albedo, and frequently cloudy skies, dampening the late March surges. Then, a return to sunny and warm weather initiated a new surge, once again producing flows well above median values. Flows are likely to decline again, during the period of unsettled weather later this week and weekend, and new snow may delay the re-emergence of the merged dust layers observed at the old snowpack surface during our site visit on April 11th resulting in an initially slowly accelerating surge thereafter.

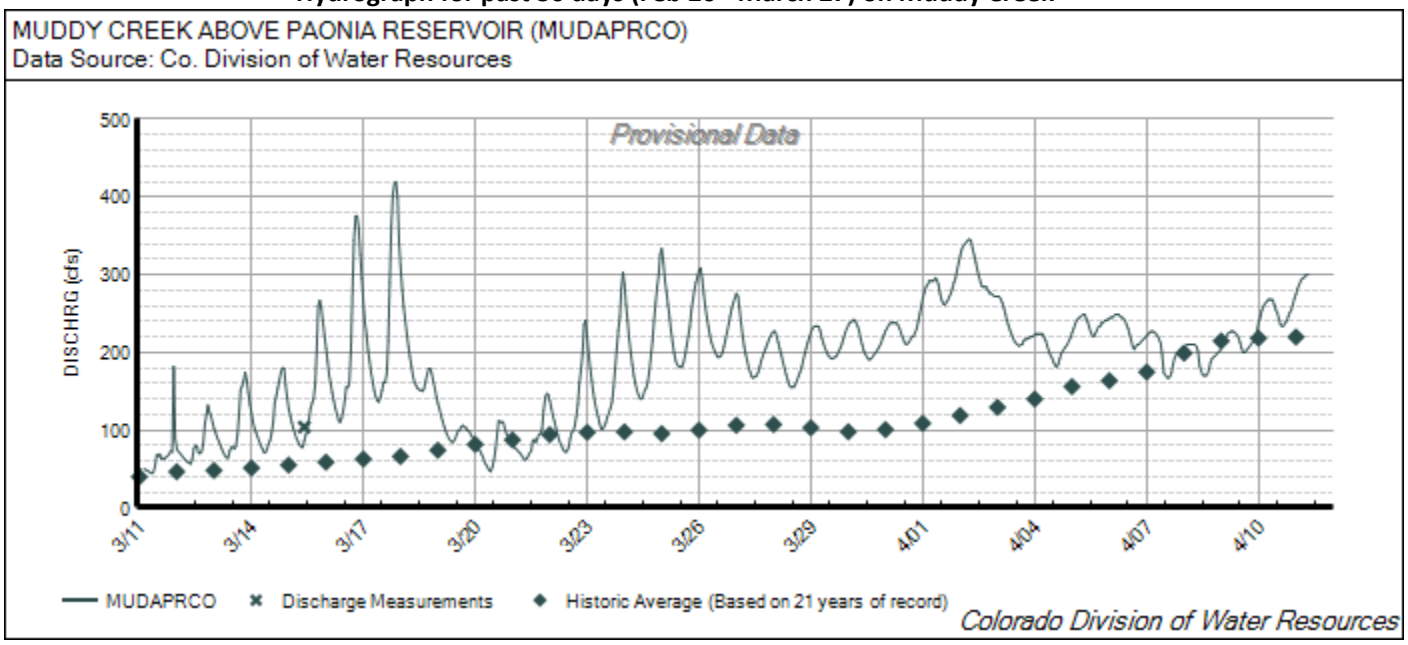
The Bureau of Reclamation reports that Muddy Creek Reservoir was 29% full as of April 10th, 99.3% of average storage for this date. The photo aboveshows the reservoir pool at mid-day on April 11th with the western aspects of the alpine Ragged Mountains in the distance. Snowcover on those western aspects is virtually gone, but more northerly aspects do retain a high percentage of snowcover above treeline, albeit thin snowcover. Given the very

early onset of snowmelt in this watershed (our snowpit on March 16 at McClure Pass showed that the snowpack on that slightly south-facing slope had been isothermal for some time), and scant remaining snowcover in the comparatively low-elevation, generally west-facing Muddy Creek watershed, it does seem possible that runoff center of mass has passed or will very soon pass through the Muddy Creek stream gauge. The Crystal River and North Fork of the Gunnison will benefit from more extensive remaining snowcover in their larger and higher-elevation headwaters containing a larger proportion of north-facing terrain than Muddy Creek.





Hydrograph for past 30 days (Feb 26 - March 27) on Muddy Creek



CODOS UPDATE FOR PARK CONE SITE:
VISITED APRIL 9, 2012

Summary | Snowpack | Melt Rate | Stream Flows | Previous Update

SUMMARY

Sustained periods of unseasonably warm air temperatures and exposed dust at the snowpack surface during late March and early April have, together, initiated accelerating rates of snowmelt and SWE loss at some, but not all, CODOS Snotel sites. Some CODOS Snotel sites report significant declines in SWE approaching the lowest values in the period of record (for a given date) or even falling outside of the historic range. Those sites *may* have experienced Peak SWE for WY 2012 in early or mid-March. Recent CODOS snowpits near those CODOS sites mirror those losses of SWE.

In contrast, other CODOS Snotel sites and CODOS snowpits show only small losses of SWE. At those sites, energy inputs from warm air and direct absorption of solar energy by dust at the snowpack surface was consumed in warming the snowpack towards an isothermal state at 0° C, as a precursor to the loss of SWE and onset of snowmelt runoff. Since our prior site visit on March 14 the snowpack at the Park Cone CODOS site, an open meadow immediately adjacent to the forested Snotel site, has lost all cold content and more than 50% of its SWE.

The National Weather Service expects warming weather in the Central Mountains through Wednesday with strong SW'ly winds developing on Wednesday afternoon ahead of a cooler but largely dry airmass. Somewhat more unsettled and cooler weather will finish the week and run through the weekend, including slight chances for snow showers each day, with temperatures perhaps even falling below seasonal norms by Friday and the weekend.

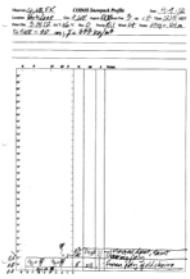
SNOWPACK DISCUSSION

The snowcover at the Park Cone CODOS site, in an open meadow immediately adjacent to the forested Park Cone Snotel site, has undergone complete warming since our March 14 snowpit and is rapidly melting, exposing large patches of open ground between thin patches of remaining snowcover. The site is likely to be snowfree in a matter of days. Dust loading at Park Cone is much less intense than at our Senator Beck Basin study sites but has been sufficient to absorb additional solar energy at the snowpack surface and contribute to this ablation of the snowcover.

On March 14th the snowpack at our CODOS snowpit site was 28" (70 cm) deep and most of the snowpack consisted of very weak "depth hoar" grains; mean snowpack temperature was -3.7° C. Dust event D4 was clearly evident on the snow surface at the snowpit and in terrain around Taylor Reservoir. SWE content in the snowpit was 7.1" (181 mm) and mean density of the snowpack was 238 kg/m3 (23.8% water content). As a result of the subsequent, prolonged period of warm, dry, and sunny weather, and some additional small reductions in snow albedo from additional dust events, the snowpack on April 9th was isothermal (0°C) and contained only 3.15" (80 mm) of SWE, a loss of nearly 4" of SWE (101 mm) since March 14; total snow depth was a scant 9" (23 cm) and density had risen to 333 kg/m3 (33.3%).

As seen from the overlook of Taylor Reservoir near our CODOS site, the valley floor above the reservoir was essentially snow free, as were south-facing slopes adjoining the reservoir. North-facing terrain still presented extensive but visibly shallow snowcover. The reservoir itself was still iced over.

April 9, 2012:



April 9th pit profile

Taylor Reservoir with Sawatch & Collegiate ranges in background

April 9th pit

Frank Kugel at the pit site

Fillled-in April pit and exposed March pit site

March 14, 2012:

March 14 pit profile

Taylor Reservoir with Sawatch & Collegiate ranges in background

March 14th pit

MELT RATE

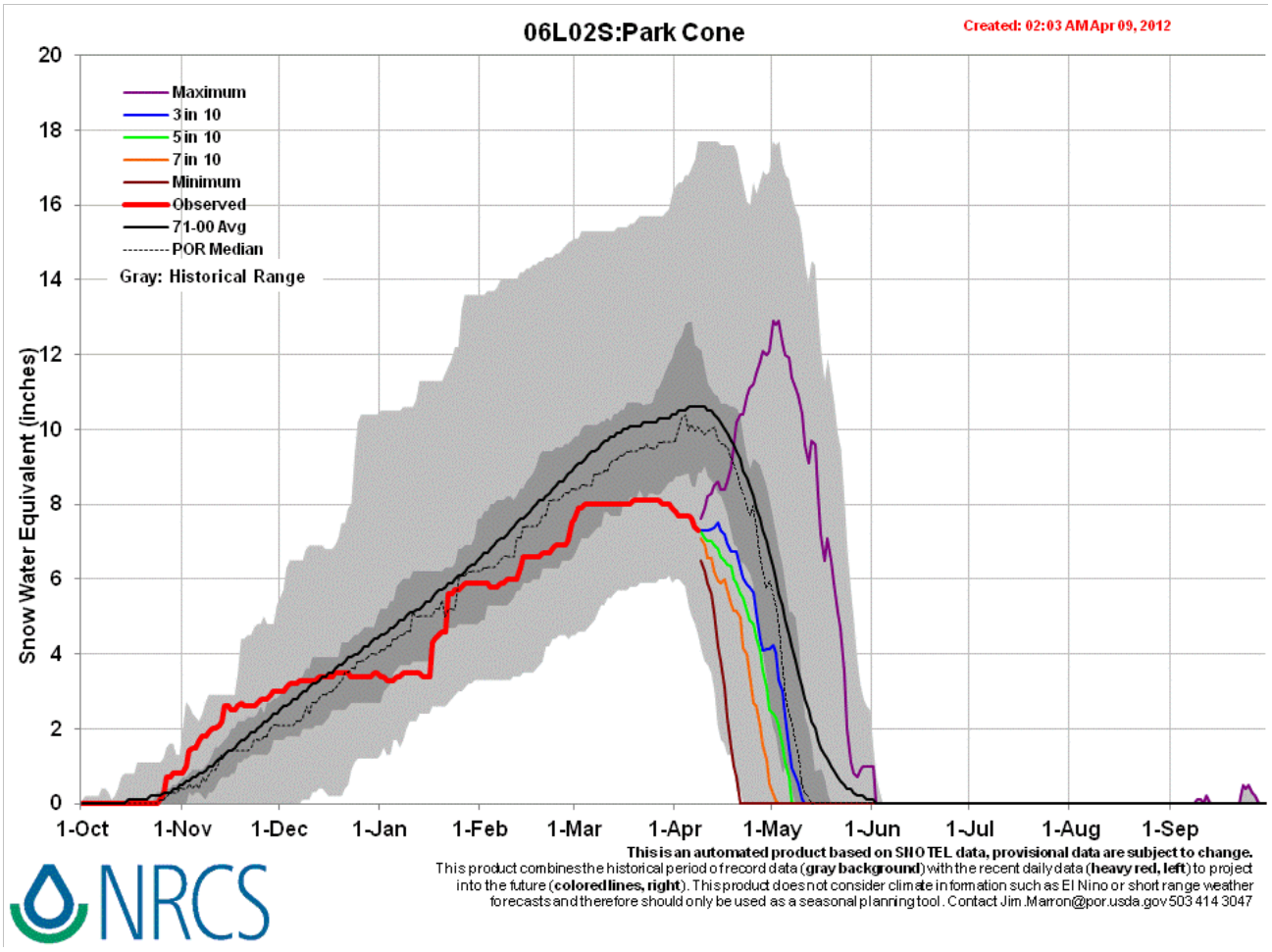
The Park Cone Snotel site, which is partially shaded by adjoining trees, has shown only a 1" loss of SWE since mid-March and retains about 7" of SWE. That melt rate falls well short of mean melt rates in prior seasons. However, as described above, melt rates in the open meadow adjacent to the Snotel station were four times more rapid, with a loss of 4" of SWE in the same period. This differential can be largely explained by the much larger amount of incoming (short wave) solar radiation reaching the snowpack surface (and subsurface) in the open meadow, compared to the tree-shaded Snotel site; actual (measured, rather than perceived) air temperatures in the trees and in the open meadow would not vary greatly between the two sites during daylight hours.

As snowcover becomes thoroughly wetted and thins, solar energy is transmitted efficiently and can reach the ground (or Snotel snow pillow) itself, further accelerating snowmelt rates. Melt rates at the Upper Taylor Snotel farther up the Taylor River valley have been much higher than at Park Cone and have reached snow all gone (SAG), perhaps due to different site characteristics. Higher still, and west of the Taylor River drainage, the Schofield Pass Snotel (see snowmelt analysis table and SNOTEL graph) has reported smaller losses in SWE since mid-March, following some gain in SWE related to the storm delivering dust event D4 on March 18. These Schofield Pass melt rates fall well short of those shown in the melt rate analysis table for that site. Like our Senator Beck Study Plot, the snowpack at Schofield Pass very likely still retains some cold content and is not yet fully isothermal at 0° C.

Park Cone SNOTEL Snowmelt Season Summary Data

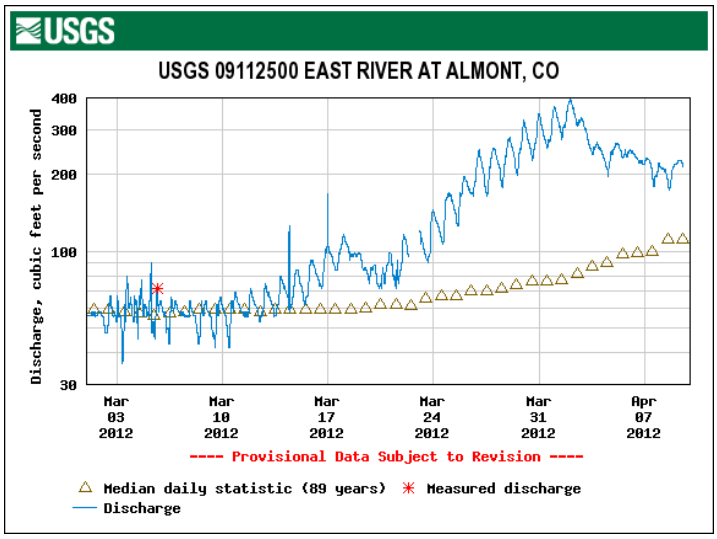
	Date Peak SWE	Peak SWE	Days to SAG	Post-Peak Added SWE	Adjusted Daily Mean Loss SWE	Period Mean Temp
WY 2006	4/7/2006	11.3	31	0.9	0.39	3.7
WY 2007	4/18/2007	7.8	17	0.5	0.49	4.5
WY 2008	4/14/2008	17.7	47	2.8	0.44	3.8
WY 2009	4/6/2009	13.2	38	1.4	0.38	3.5
WY 2010	4/10/2010	10.8	41	2.4	0.32	3.1
WY 2011	4/7/2011	14.5	54	4.1	0.34	3.0
Max	4/18	17.7	54	4.1	0.49	4.5
Min	4/6	7.8	17	0.5	0.32	3.0
Range	13	9.9	37	3.6	0.17	1.5

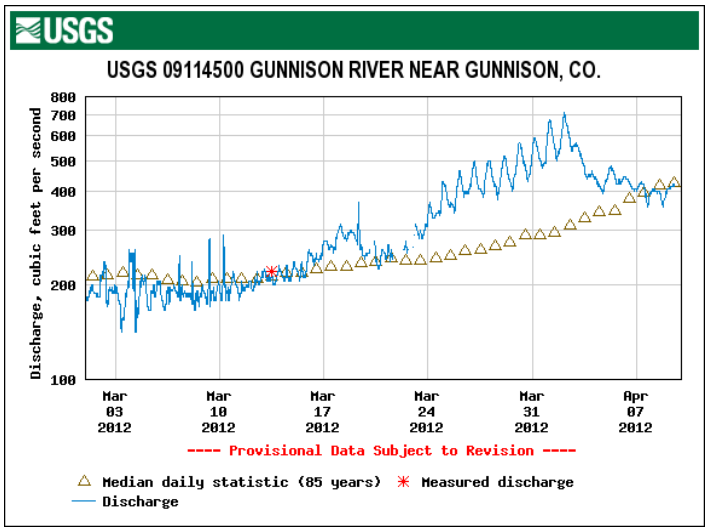
Adjusted Daily Mean Loss SWE rates include additional SWE received after date of Peak SWE



STREAM FLOWS

Streamflow behavior at the USGS Gunnison River near Gunnison and East River at Almont gauges show similar declines in early April, after significant surges in late March reaching very high flows compared to median levels at those gauges, for that period. Unsettled weather on April 2, with snow flurries, ushered in cooler air and cloudier skies for the following several days, with another weak weather system following on the 5th. Interestingly, the East River flows then stabilized flows at roughly double the median values, while the Gunnison near Gunnison was reduced to median flow levels.





CODOS UPDATE FOR RABBIT EARS PASS: VISITED APRIL 10, 2012

Summary | Snowpack | Melt Rate | Stream Flows | Forecast | Previous Update

SUMMARY

Sustained periods of unseasonably warm air temperatures and exposed dust at the snowpack surface during late March and early April 2012 have, together, initiated accelerating rates of snowmelt and SWE loss at some, but not all, CODOS Snotel sites. Some CODOS Snotel sites report significant declines in SWE approaching the lowest values in the period of record (for a given date) or even falling outside of the historic range. Those sites *may* have experienced Peak SWE for WY 2012 in early or mid-March. Recent CODOS snowpits near those CODOS sites mirror those losses of SWE.

In contrast, other CODOS Snotel sites and CODOS snowpits show only small losses of SWE. At those sites, energy inputs from warm air and direct absorption of solar energy by dust at the snowpack surface was consumed in warming the snowpack towards an isothermal state at 0° C, as a precursor to the loss of SWE and onset of snowmelt runoff. Since our prior site visit on March 14 the snowpack at the Rabbit Ears Pass CODOS site has lost its remaining cold content and is now fully isothermal.

The National Weather Service expects warming weather in the Colorado mountains through Wednesday with strong SW'ly winds developing Wednesday afternoon ahead of a cooler but largely dry airmass. Unsettled and cooler weather will finish the week and run through the weekend, including chances for rain and/or snow showers each day.

SNOWPACK DISCUSSION

The snowcover at the Rabbit Ears Pass CODOS site has undergone complete warming since our March 14 snowpit and is now fully isothermal. As was observed during our March field work, dust loading seems stronger on the eastern side of the Rabbit Ears Pass plateau than at our CODOS site farther west, where it is comparable to that observed at Grizzly Peak, Berthoud Pass and Willow Creek Pass. While spatially variable, albedo reduction throughout this locale has been sufficient to absorb additional solar energy at the snowpack surface and contribute to ablation of the snowcover.

On March 15th the snowpack at our Rabbit Ears Pass CODOS snowpit site was 60" (153 cm) deep and mean snowpack temperature, at -1.0 C, was approaching isothermal. Dust event D4 was clearly evident on the snow surface at the snowpit and in terrain around Rabbit Ears Pass. SWE content in the snowpit was 19.3" (490 mm) and mean density of the snowpack was 322 kg/m^3 (32.2% water content). As a result of the subsequent, prolonged period of warm, dry, and sunny weather, and further reductions in snow albedo from additional dust events, the snowpack on April 10th was fully isothermal at 0°C and wet or very wet snow throughout. Total SWE had fallen to 12.6" (319 mm), a loss of 6.7" (171 mm) since March 15; total snow depth was down to 30" (77 cm) and density had risen to 389 kg/m^3 (38.9% water content).

April 10, 2012:

March 15, 2012:

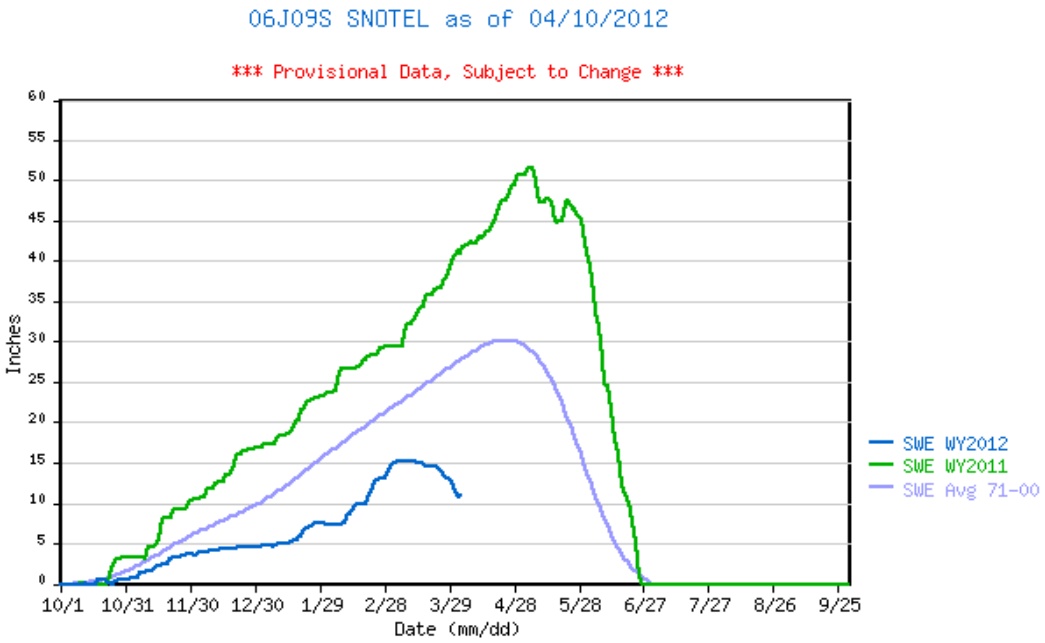
MELT RATE

The Rabbit Ears Pass Snotel site, despite being shaded by adjoining trees, has also recorded significant snowmelt losing more than 4" of SWE since mid-March. SWE data have been interrupted since April 3rd but melt rates were up to 0.6" of SWE loss per day at that time and accelerating.

Rabbit Ears SNOTEL Snowmelt Season Summary Data

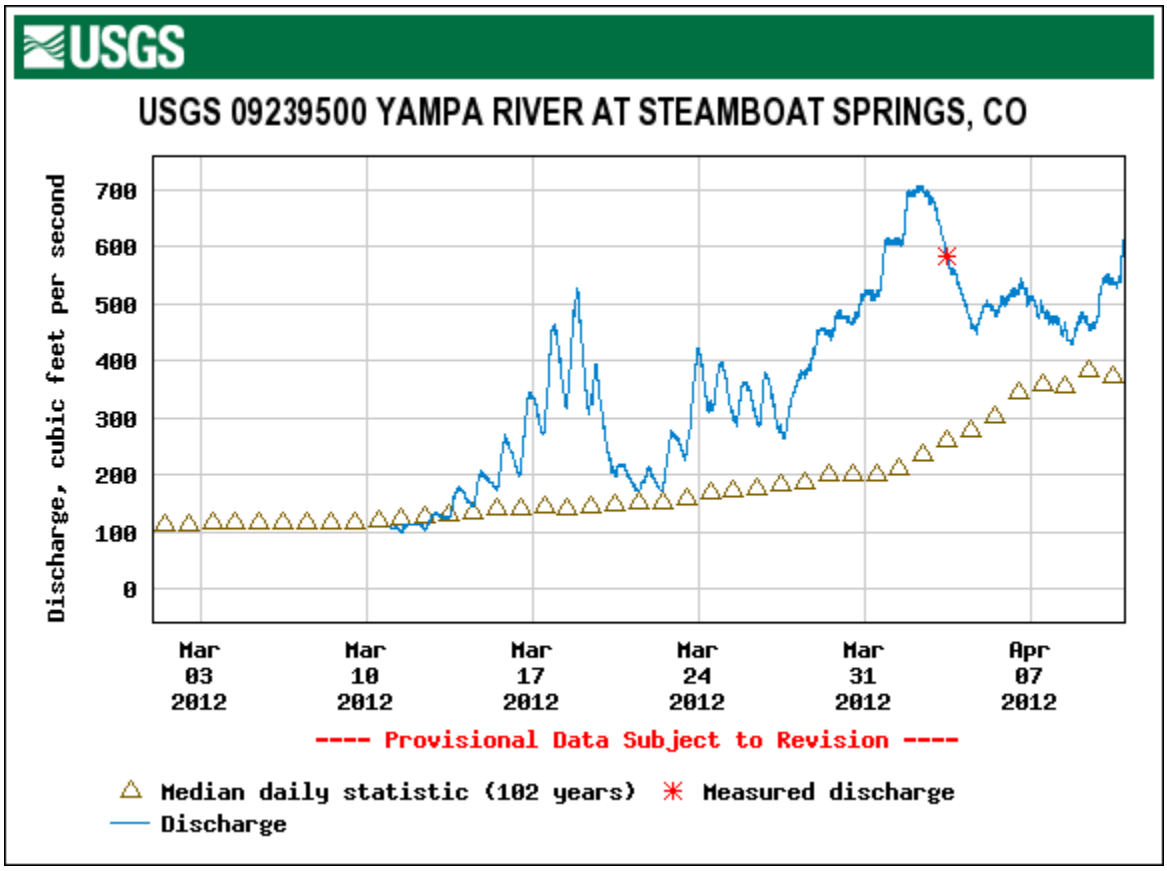
	Date Peak SWE	Peak SWE	Days to SAG	Post-Peak Added SWE	Adjusted Daily Mean Loss SWE	Period Mean Temp
WY 2006	4/9/2006	38.0	50	2.3	0.81	4.6
WY 2007	4/14/2007	22.7	37	2.9	0.69	4.9
WY 2008	4/15/2008	38.0	62	8.5	0.75	4.1
WY 2009	4/21/2009	32.8	40	3.8	0.92	5.7
WY 2010	5/16/2010	19.2	22	2.1	0.97	7.9
WY 2011	5/6/2011	51.6	52	5.3	1.09	7.3
Max	5/16	51.6	62	8.5	1.09	7.9
Min	4/9	19.2	22	2.1	0.69	4.1
Range	38	32.4	40	6.4	0.40	3.8

Adjusted Daily Mean Loss SWE rates include additional SWE received after date of Peak SWE



STREAM FLOWS

Streamflow behavior at the USGS Yampa River at Steamboat Springs gauge shows significant surging in late March reaching very high flows compared to median levels at that gauge, for that period. Unsettled weather in early April brought cooler temperatures, small amounts of new snow that briefly increased snow albedo, and frequently cloudy skies, dampening the late March surge in streamflow back down to near-median values. The recent return to sunny and warm weather has initiated a new surge, once again producing flows well above median values.



CODOS UPDATE FOR SENATOR BECK BASIN STUDY AREA: VISITED APRIL 7-8, 2012

Summary | Snowpack | Melt Rate | Stream Flows |Wind Behavior | Previous Update | pdf

SUMMARY

Sustained periods of unseasonably warm air temperatures and exposed dust at the snowpack surface during late March and early April have, together, initiated accelerating rates of snowmelt and SWE loss at some, but not all, CODOS Snotel sites. Some CODOS Snotel sites report significant declines in SWE approaching the lowest values in the period of record (for a given date) or even falling outside of the historic range. Those sites *may* have experienced Peak SWE for WY 2012 in early or mid-March. Recent CODOS snowpits near those CODOS sites mirror those losses of SWE.

In contrast, even with comparable reductions in snow albedo from the same exposed dust layers, other CODOS Snotel sites and CODOS snowpits show only small losses of SWE. Energy inputs from warm air and direct absorption of solar energy by dust at the snowpack surface was consumed in warming the snowpack towards an isothermal state at 0° C at those generally higher or cooler (N'ly aspect) sites. Our recent snowpits at Senator Beck Basin, at the Swamp Angel and Senator Beck Study Plots, demonstrate this difference in snowmelt rates driven by differences in elevation (slope and aspect are identical at both sites), as the higher Senator Beck Study Plot is only now approaching isothermal.

The National Weather Service expects warming weather in the western San Juan Mountains through Tuesday, April 10th, with a slight chance for afternoon showers on Tuesday. Another round of strong SW'ly winds will develop on Tuesday afternoon. Somewhat more unsettled and cooler weather will finish the week, including slight chances for rain and/or snow showers each day, with temperatures perhaps even falling below seasonal norms by Friday and the weekend.

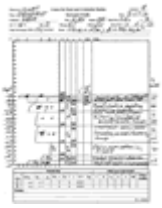
SNOWPACK DISCUSSION

Despite near-constant exposure of dust at the snowpack surface, the Senator Beck Study Plot, at 12,186', has lost essentially no SWE since our March 28 Update, but the mean snowpack temperature has risen from -3.7° C on March 27 to -1.6° C on April 7. Melt at the Senator Beck Study Plot snowpack surface did result in substantial melt water flux into the upper snowpack where that free water encountered cold snow and refroze, as layers of clear iceup to 2-3 cm thick. Meanwhile, warming from below elevated snow temperatures to near-zero values in the bottom two-thirds of the snowpack.

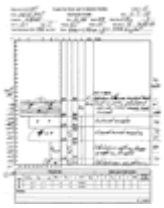
Minor snow squalls associated with dust-on-snow event D8, April 6th, left a thin layer of dry and dusty new snow scattered over the alpine terrain of Senator Beck Basin. Those patches exhibit a higher albedo than the old snow surface containing D7/6/5/4 dust in between them and will require a day or two of direct sun to melt and merge with the much lower albedo snow underneath.

On March 26th the snowpack at the lower elevation Swamp Angel Study Plot, at 11,060', was effectively isothermal and contained 21.3" (542 mm) of SWE; depth was 61" (156 cm). By April 8th, SWE and total depth had fallen to 17.0" (433 mm) and 42.5" (108 cm) respectively; temperatures were still isothermal. Dust layer D8 had merged with the D7/6/5/4 dust, at the snowpack surface (see photo).

Senator Beck Study Plot:



SBSP Pit profile for March 27, 2012



SBSP Pit profile for April 7, 2012

After re-filling the snow pit on April 7, 2012

Pit on April 7, 2012

Swamp Angel Study Plot:

SASP Pit profile for March 26, 2012

SASP Pit profile for April 8, 2012

SASP Snow Pit on April 8, 2012

Pit on April 8, 2012

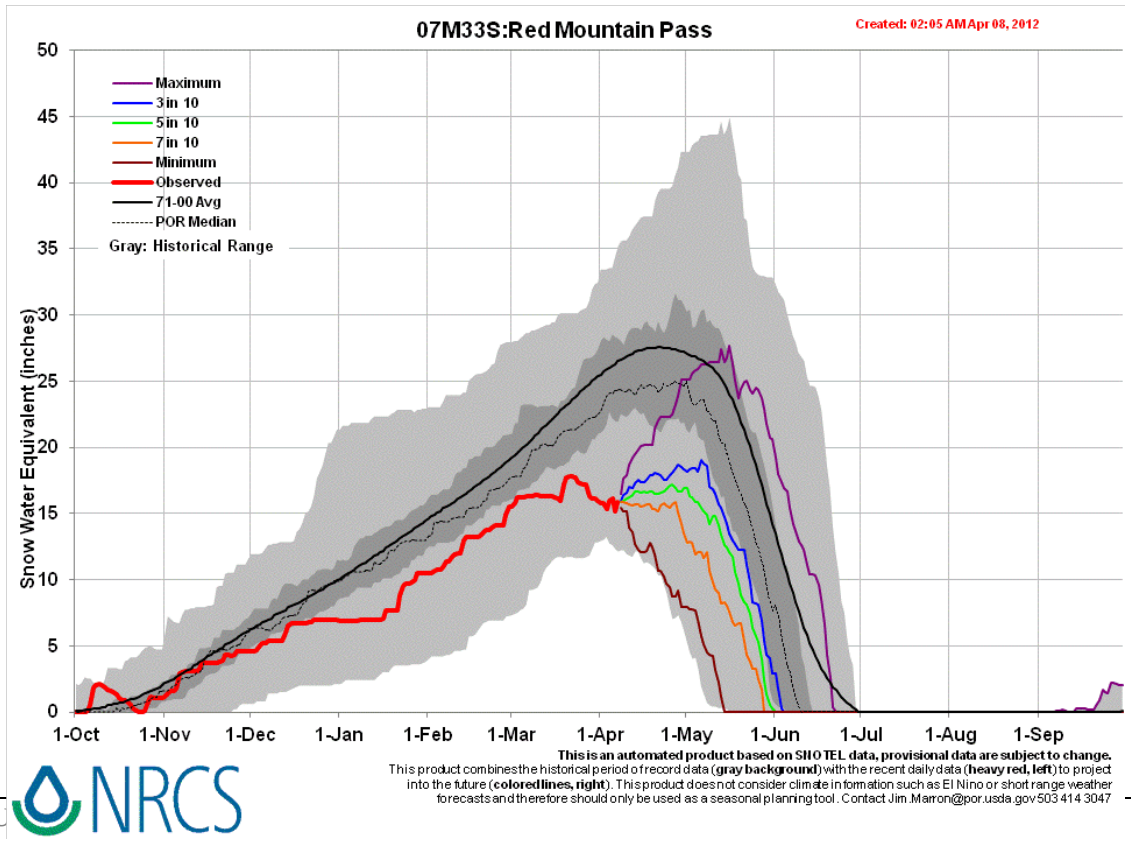
MELT RATE

Between March 27th and April 3rd the Red Mountain Pass Snotel, at 11,200', lost 2" of SWE before a small rebound, much less than the 4.3" (109 mm) loss measured at the Swamp Angel Study Plot from March 26 to April 8. The Red Mountain Pass Snotel site is closely bordered by tall trees to the east, south, and southwest. Farther west, the Lizard Head Pass Snotel (see snowmelt analysis table and SNOTEL graph), at 10,200', lost 5" of SWE over the same period and the extremely low SWE levels are barely within the period of record range. Melt rates have approached 1" of SWE loss per day in recent days at the Lizard Head Pass Snotel.

Red Mountain Pass SNOTEL Snowmelt Season Summary Data

	Date Peak SWE	Peak SWE	Days to SAG	Post-Peak Added SWE	Adjusted Daily Mean Loss SWE	Period Mean Temp
WY 2006	4/8/2006	24.4	50	1.2	0.51	3.1
WY 2007	5/9/2007	23.7	34	1.7	0.75	4.7
WY 2008	4/14/2008	34.4	66	4.3	0.59	2.9
WY 2009	4/19/2009	27.5	37	1.8	0.79	4.3
WY 2010	4/8/2010	24.2	54	3.7	0.52	1.5
WY 2011	5/22/2011	33.7	33	1.4	1.06	6.8
Max	5/22	34.4	66	4.3	1.06	6.8
Min	4/8	23.7	33	1.2	0.51	1.5
Range	45	10.7	33	3.1	0.55	5.3

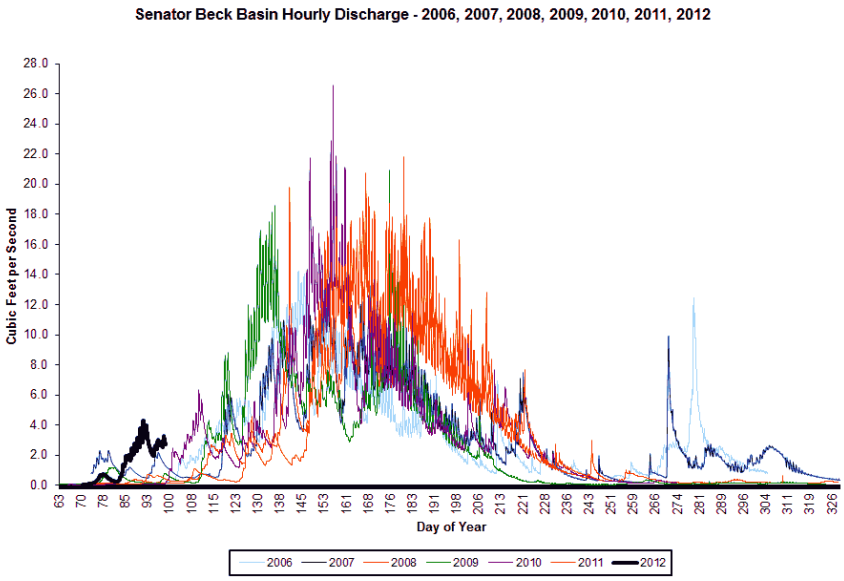
Adjusted Daily Mean Loss SWE rates include additional SWE received after date of Peak SWE

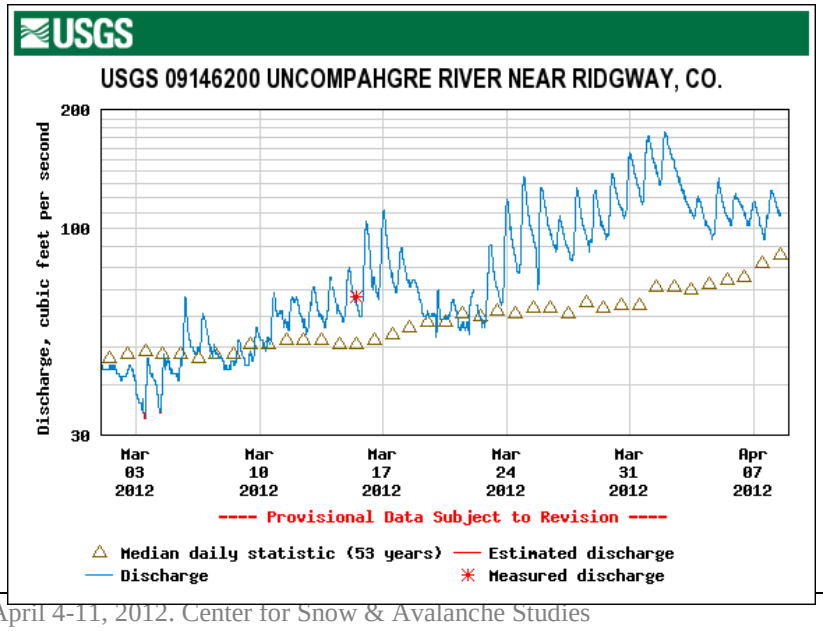


STREAM FLOWS

Streamflow behavior at the CSAS's Senator Beck stream gauge and the USGS Uncompahgre at Ridgway gauge show similar declines in early April, after significant surges in late March. Unsettled weather on April 2, with snow flurries, ushered in cooler air and cloudier skies for the following several days, with another weak weather system following on the 5th. The combination of cooler temperatures, small amounts of new snow briefly increasing snow albedo, and frequently cloudy skies dampened the preceding surge in streamflows. On April 8, surface flows from the rapidly melting sunny slopes at the bottom end of Senator Beck Basin were once again increasing, as was the flow at the stream gauge, as seen in the video link below. Senator Beck Basin total discharge remains quite small, to-date, as much of the upper Basin snowpack is only now approaching isothermal snow temperatures, at 0° C

The effects of early April weather are also seen in the USGS gauge data from the Animas River at Durango, Dolores River at Dolores, and San Miguel River near Placerville.

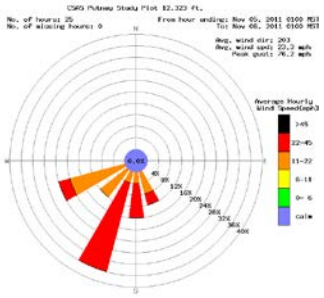




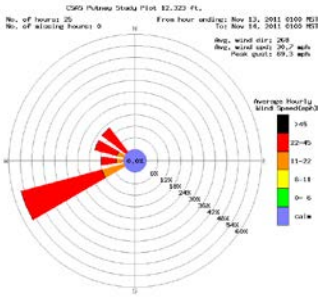
WIND BEHAVIOR

The following graphs show wind behavior during the Water Year 2012 dust-on-snow events at our Putney Study Plot (best wind data for Senator Beck Basin Study Area and Red Mountain Pass). We have estimated beginning and end times of each event based on observations from Silverton, CO. For more on this wind analysis, see the CODOS dust log and wind rose table.

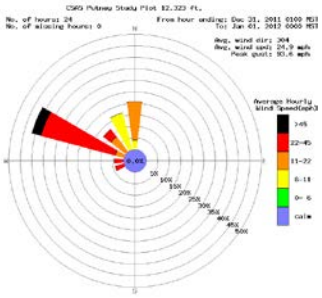
D1: Nov 5, 2011



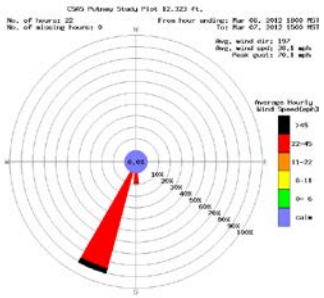
D2: Nov 13, 2011



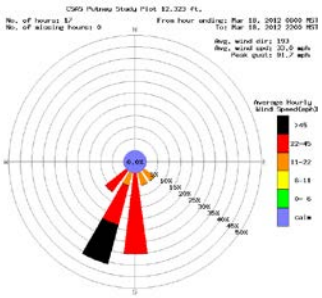
D3: Dec 3, 2011



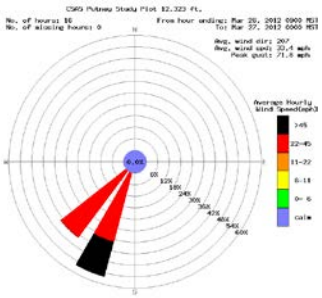
D4: March 6, 2012



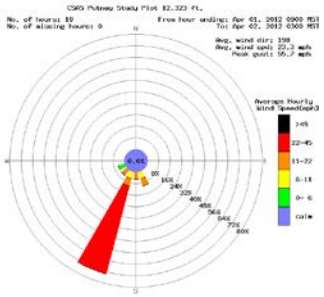
D5: March 18, 2012



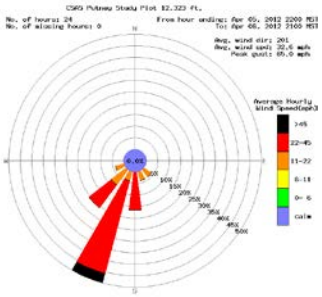
D6: March 26, 2012



D7: April 1, 2012

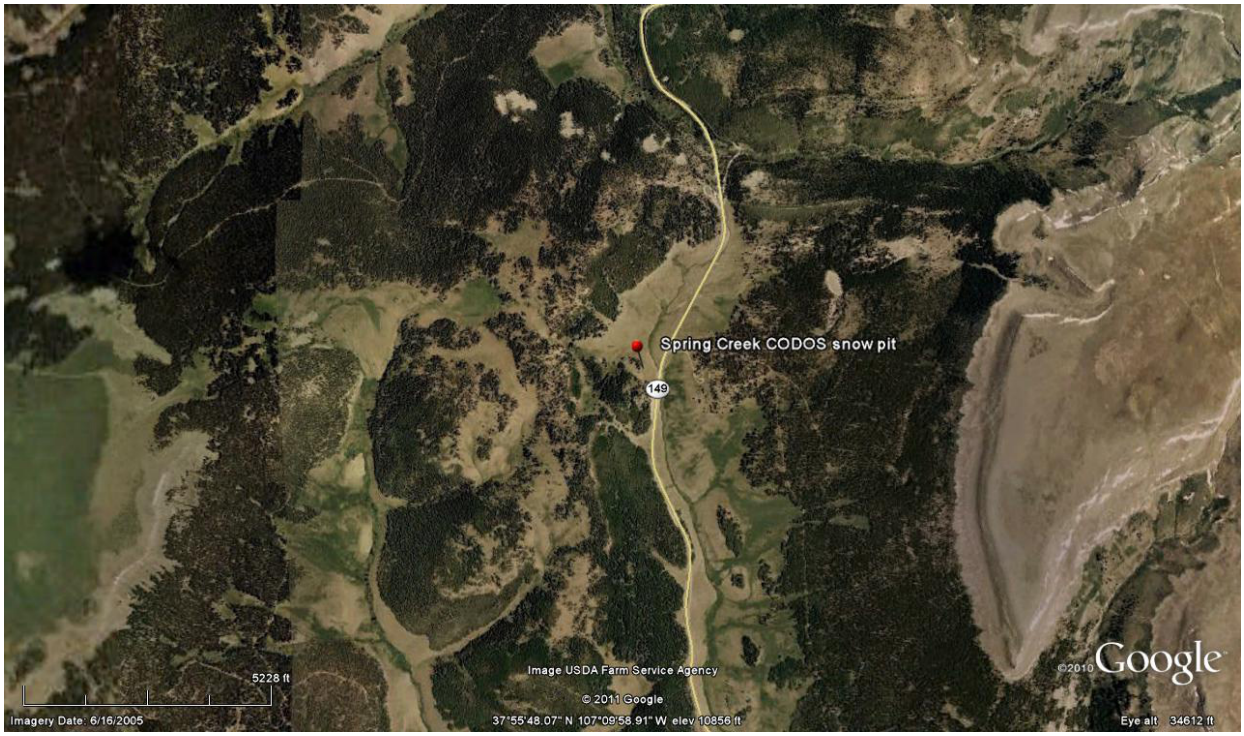


D8: April 6, 2012



CODOS UPDATE FOR SPRING CREEK PASS: VISITED APRIL 9, 2012

Summary | Snowpack | Melt Rate | Stream Flows | Previous Update



SUMMARY

Sustained periods of unseasonably warm air temperatures and exposed dust at the snowpack surface during late March and early April 2012 have, together, initiated accelerating rates of snowmelt and SWE loss at some, but not all, CODOS Snotel sites. Some CODOS Snotel sites report significant declines in SWE approaching the lowest values in the period of record (for a given date) or even falling outside of the historic range. Those sites *may* have experienced Peak SWE for WY 2012 in early or mid-March. Recent CODOS snowpits near those CODOS sites mirror those losses of SWE.

In contrast, other CODOS Snotel sites and CODOS snowpits show only small losses of SWE. At those sites, energy inputs from warm air and direct absorption of solar energy by dust at the snowpack surface was consumed in warming the snowpack towards an isothermal state at 0° C, as a precursor to the loss of SWE and onset of snowmelt runoff. As of our site visit on April 9, and since our prior site visit on March 17, snowcover has disappeared from the Spring Creek Pass CODOS site, while the nearby Slumgullion Pass Snotel was reporting 11.8" of SWE and 38" of snowpack depth.

[*This forecast discussion is current as of Thursday, April 12*] Strong SW'ly winds and showers developed on Wednesday afternoon ahead of a cooler airmass bringing unsettled and cooler weather for the remainder of this week, with chances for snow showers each day and temperatures below seasonal norms. Chances increase for more significant snow amounts over the weekend and may result in state-wide restoration of higher snow albedo. Showers may continue into the early work week but high pressure is expected to return to the State by mid-week with dry and warmer weather.

SNOWPACK DISCUSSION

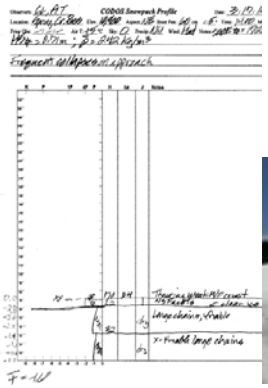
As of April 9th, snowcover has almost disappeared from the CODOS Spring Creek Pass snowpit site, with only small patches of very thin and very dirty snow scattered among large patches of bare ground. Almost no other snowcover remains along the valley corridor leading to Spring Creek Pass from Creede. Snowcover in the higher alpine terrain of the upper Rio Grande valley appeared, from a long distance, to present reduced albedo comparable to that seen in the western San Juan Mountains the day prior. Meanwhile, as of April 9th, the Slumgullion Pass Snotel reported nearly 12" of SWE. Based on confirmation of dust events D5, D6, D7, and D8 in the San Luis Valley, and in our Wolf Creek Pass profile on April 9, we are confident that the Spring Creek CODOS site also received these additions to the D4 dust that we observed at the snowpack surface on March 17. Clearly, the snowpack at our CODOS site became isothermal in the interim since our March 17 visit and then rapidly melted.

April 9, 2012:




No Pit (Snow All Gone) | view of pit site | Spring Creek pit site | Baldy Cinco | Rio Grande headwaters

March 17, 2012:





Pit profile | view of pit site | March 17th pit | Rio Grande headwaters

MELT RATE

[*This discussion is current as of Thursday, April 12, 2012*] On March 17 we measured 27.5" of snow containing 6.8" of SWE at our Spring Creek Pass snowpit site; mean snowpack temperature on that date was -1.6° C. Just a few days later, Peak SWE of 12.0" occurred on/about March 22nd at the Slumgullion Snotel (elev. 11,440'), the closest Snotel to our Spring Creek Pass CODOS site, almost a month earlier than normal. That Peak SWE value was produced by the storm that delivered dust event D5, the last significant snowfall in this locale. Since Peak SWE, melt rates have been slow at this Snotel,as seen below. (Small increases in SWE up to 12.4" in late March were reported on days with no precipitation and may reflect rapid settlement of wet snow.) However, as at other CODOS sites, melt rates in the open meadow where our Spring Creek Pass CODOS snowpits are dug were higher and the snowpit plot has just reached snow all gone (SAG), losing almost 7" of SWE after becoming isothermal during the warm and sunny weather of late March.

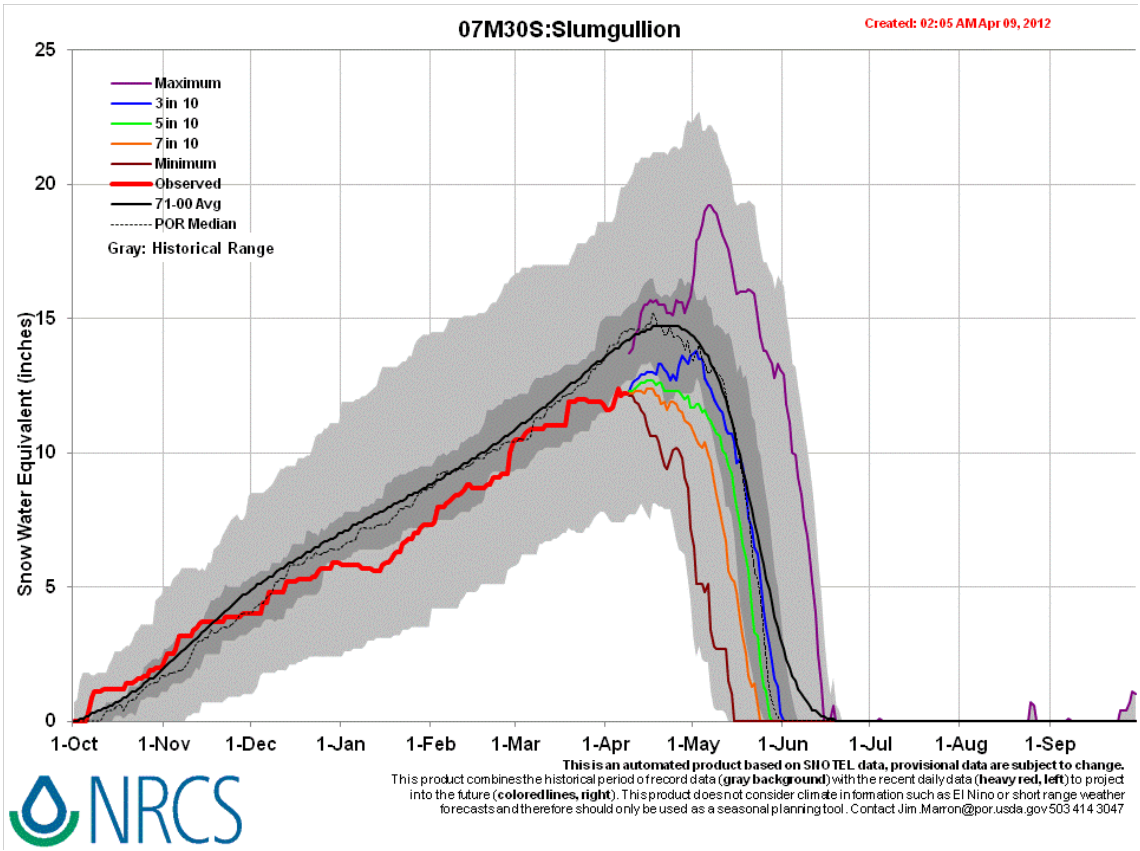
Meanwhile, during this period, the Beartown Snotel station (see snowmelt analysis table and SNOTEL graph), at 11,600', has reported considerable loss of SWE since March 21st, losing almost 10" of SWE since peaking almost a month early at 17.1" after the storm delivering dust event D5.

Farther south, the somewhat lower elevation Wolf Creek Summit Snotel (11,000') (see snowmelt analysis table and SNOTEL graph) has characteristically recorded a slower snowmelt rate, losing only 3" SWE since peaking on March 23rd at 24.8". Dust loading at our Wolf Creek CODOS site is comparable to our Senator Beck Basin site, and our Wolf Creek CODOS snowpit on April 9 found 12.6" of SWE, a loss of 9.3" of SWE since our March 17 snowpit at that site.

Slumgullion Pass SNOTEL Snowmelt Season Summary Data

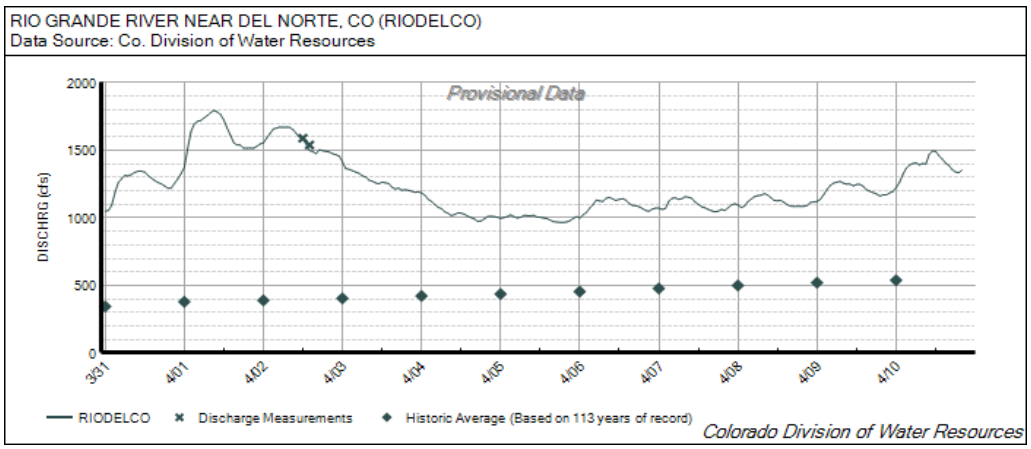
	Date Peak SWE	Peak SWE	Days to SAG	Post-Peak Added SWE	Adjusted Daily Mean Loss SWE	Period Mean Temp
WY 2006	4/17/2006	15.9	38	0.4	0.43	2.2
WY 2007	4/18/2007	16.6	50	3.6	0.40	3.3
WY 2008	4/20/2008	19.6	49	2.3	0.45	2.9
WY 2009	4/21/2009	16.0	27	0.4	0.61	4.5
WY 2010	4/11/2010	14.7	45	2.6	0.38	1.1
WY 2011	5/4/2011	16.9	35	2.1	0.54	4.1
Max	5/4	19.6	50	3.6	0.61	4.5
Min	4/11	14.7	27	0.4	0.38	1.1
Range	24	4.9	23	3.2	0.22	3.4

Adjusted Daily Mean Loss SWE rates include additional SWE received after date of Peak SWE



STREAM FLOWS

[*This discussion is current as of Thursday, April 12, 2012*] Streamflow at the Rio Grande at Del Norte gauge have been sustained at levels well above daily median discharge rates since mid-March, surging during the prolonged period of dry, very warm, and sunny weather of late March, with multiple dust layers merged at the snowpack surface. Since our site visit on April 9, a significant surge produced discharge reaching 2,000 cfs at that gauge on the night of April 11/12, almost 4x the median flow for that date, at the same time that dust event D8 has fully emerged in the western San Juan Mountains (Senator Beck Basin is only 18 miles NW of the Beartown Snotel) and with very high temperatures earlier this week.



CODOS UPDATE FOR WILLOW CREEK PASS: VISITED APRIL 10, 2012

Summary | Snowpack | Melt Rate | Forecast | Stream Flows | Previous Update

SUMMARY

Sustained periods of unseasonably warm air temperatures and exposed dust at the snowpack surface during late March and early April 2012 have, together, initiated accelerating rates of snowmelt and SWE loss at some, but not all, CODOS Snotel sites. Some CODOS Snotel sites report significant declines in SWE approaching the lowest values in the period of record (for a given date) or even falling outside of the historic range. Those sites *may* have experienced Peak SWE for WY 2012 in early or mid-March. Recent CODOS snowpits near those CODOS sites mirror those losses of SWE.

In contrast, other CODOS Snotel sites and CODOS snowpits show only small losses of SWE. At those sites, energy inputs from warm air and direct absorption of solar energy by dust at the snowpack surface was consumed in warming the snowpack towards an isothermal state at 0° C, as a precursor to the loss of SWE and onset of snowmelt runoff. Since our prior site visit on March 15, the snowcover has disappeared from the Willow Creek Pass CODOS site, but the nearby SNOTEL still retains some snowpack.

The National Weather Service expects warming weather in the Colorado mountains through Wednesday with strong SW'ly winds developing on Wednesday afternoon ahead of a cooler but largely dry airmass. Unsettled and cooler weather will finish the week and run through the weekend, including chances for rain and/or snow showers each day.

SNOWPACK DISCUSSION

Snow has completely disappeared from the CODOS Willow Creek Pass site, located in an open meadow adjoining the Willow Creek Pass SNOTEL site. The adjoining forest, where the Willow Creek Pass SNOTEL and snow course are located, retains shallow and patchy snowcover, now isothermal. That SNOTEL has been reporting SWE only intermittently, with the last report 7 days ago (April 3) at 6.9" of SWE.

April 10, 2012:

no pit (Snow All Gone)

Looking SW from snow pit site

Looking NE towards snow pit site

March 15, 2012:

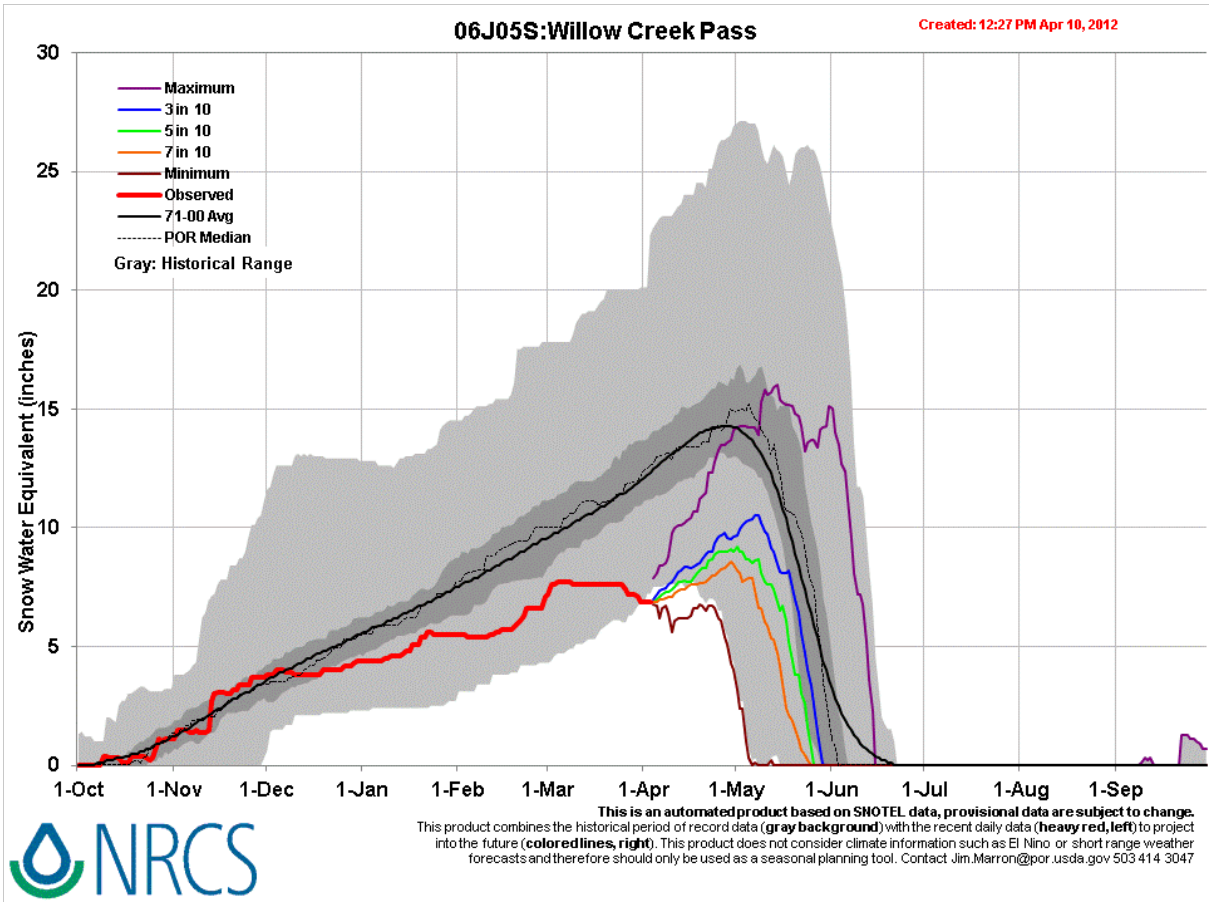
MELT RATE

Barring a currently unexpected major winter storm, Peak SWE of 7.7" has already occurred, in early March, about six weeks early, and current SWE values have dropped below the lowest quartile in this SNOTEL's period of record for this date. Recently reported melt rate at this SNOTEL fall well short of the mean daily loss rates shown in the table below, and very far short of the maximum SWE loss rate last Spring of 2.40” per day, over a 5-day period ending June 11, 2011. However, as at other CODOS sites, the melt rates in the open meadow where CODOS snowpits are dug have been higher to reach 'Snow All Gone' (SAG) than at the shaded Willow Creek Pass SNOTEL site.

Willow Creek Pass SNOTEL Snowmelt Season Summary Data

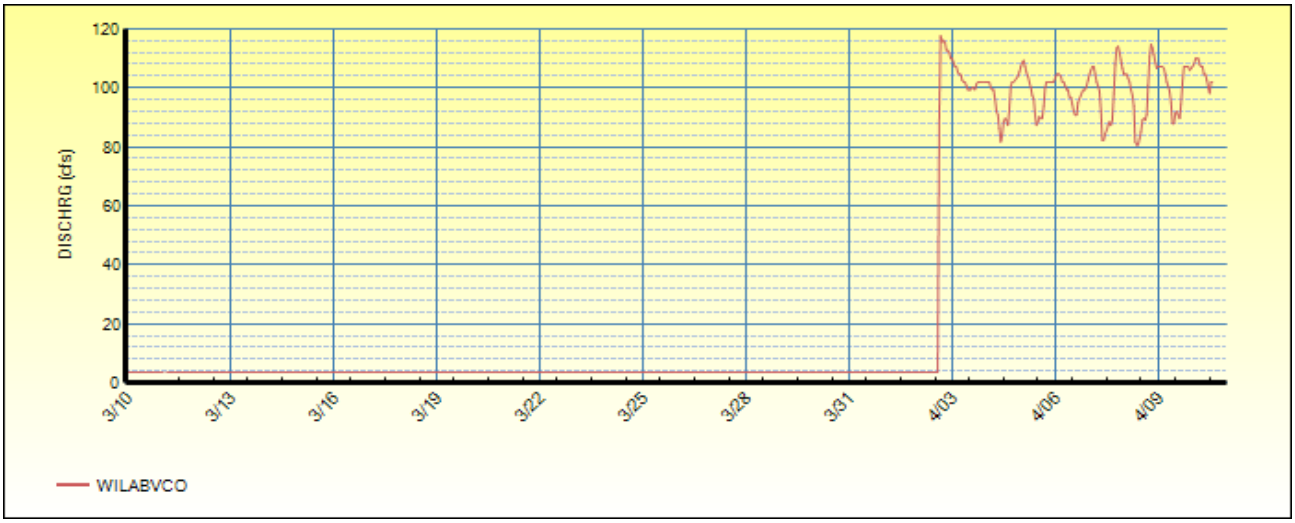
	Date Peak SWE	Peak SWE	Days to SAG	Post-Peak Added SWE	Adjusted Daily Mean Loss SWE	Period Mean Temp
WY 2006	4/27/2006	13.4	28	0.8	0.51	3.8
WY 2007	4/28/2007	16.8	37	1.7	0.50	4.5
WY 2008	5/16/2008	21.9	30	2.0	0.80	5.8
WY 2009	4/20/2009	14.7	37	3.4	0.49	4.8
WY 2010	5/16/2010	14.4	21	0.5	0.71	6.6
WY 2011	5/4/2011	27.1	43	3.8	0.72	5.4
Max	5/16	27.1	43	3.8	0.80	6.6
Min	4/20	13.4	21	0.5	0.49	3.8
Range	27	13.7	22	3.3	0.31	2.8

Adjusted Daily Mean Loss SWE rates include additional SWE received after date of Peak SWE



STREAM FLOWS

The following graph of Willow Creek Above Willow Creek Reservoir provided by the Northern Colorado Water Conservancy District began reporting in the past week; no historic flow data are provided in this graphic. However, our observations of Willow Creek on April 10 found the stream well below bank full as seen in the photo below. This photo also shows the results of last spring's very intense runoff, moving very large woody debris down the channel and causing siginifcant alterations to the channel bed and banks.



CODOS UPDATE FOR WOLF CREEK PASS: VISITED APRIL 9, 2012

Summary | Snowpack | Melt Rate | Stream Flows | Previous Update

SUMMARY

Sustained periods of unseasonably warm air temperatures and exposed dust at the snowpack surface during late March and early April 2012 have, together, initiated accelerating rates of snowmelt and SWE loss at some, but not all, CODOS Snotel sites. Some CODOS Snotel sites report significant declines in SWE approaching the lowest values in the period of record (for a given date) or even falling outside of the historic range. Those sites *may* have experienced Peak SWE for WY 2012 in early or mid-March. Recent CODOS snowpits near those CODOS sites mirror those losses of SWE.

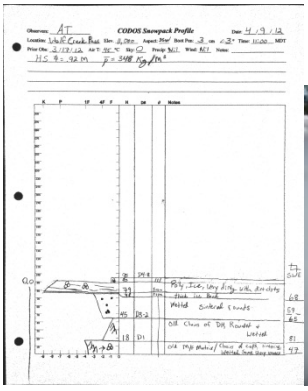
In contrast, other CODOS Snotel sites and CODOS snowpits show only small losses of SWE. At those sites, energy inputs from warm air and direct absorption of solar energy by dust at the snowpack surface was consumed in warming the snowpack towards an isothermal state at 0° C, as a precursor to the loss of SWE and onset of snowmelt runoff. As of our site visit on April 9, and since our prior site visit on March 17, the snowpack has become fully isothermal and significant snowmelt has occurred at out Wolf Creek Pass CODOS site, while the nearby Wolf Creek Summit Snotel was reporting only minor losses of SWE. Heavy dust was observed at the remaining snowpack surface producing reductions in snow albedo exceeding those observed at the Senator Beck Basin Study Area the day before.

[*This forecast discussion is current as of Thursday, April 12*] Strong SW'ly winds and showers developed on Wednesday afternoon ahead of a cooler airmass bringing unsettled and cooler weather for the remainder of this week, with chances for snow showers each day and temperatures below seasonal norms. Chances increase for more significant snow amounts over the weekend and may result in state-wide restoration of higher snow albedo. Showers may continue into the early work week but high pressure is expected to return to the State by mid-week with dry and warmer weather.

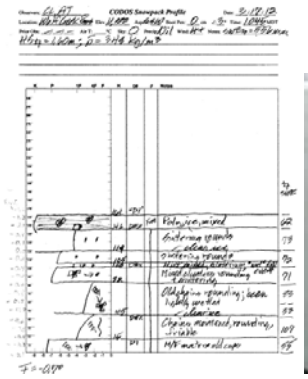
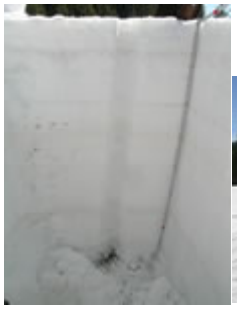
SNOWPACK DISCUSSION

As of April 9th, the CODOS Wolf Creek Pass snowpit site retained 37" (95 cm) of snowcover containing 12.6" of SWE, down from 63" in depth and 21.9" in SWE since March 17th; the snowpack was fully isothermal at 0° C throughout. Very little snowcover remains along the highway corridor leading to Wolf Creek Pass from Pagosa Springs. Meanwhile, as of April 9th, the Wolf Creek Summit Snotel reported nearly 22.9" of SWE and 56" of snow depth. Dust event D8 was clearly evident at ths snowpack surface, merged with layers D7-4. A significant dust layer in the middle of the snowpack corresponding to event D3 is more evident here than at the Senator Beck CODOS site or at any other CODOS site.

April 9, 2012:




March 17, 2012:


MELT RATE

[*This discussion is current as of Thursday, April 12*] On March 17 we measured 63" of snow containing 21.9" of SWE at our Wolf Creek Pass snowpit site; mean snowpack temperature was nearly isothermal on that date at -0.7° C. As of April 9th, the CODOS Wolf Creek Pass snowpit site retained 37" (95 cm) of snowcover containing 12.6" of SWE, a loss of 9.3" of SWE in 23 days, or 0.44" per day. Nearby, the Wolf Creek Summit Snotel (11,000') has characteristically recorded a slower snowmelt rate, losing only 3" SWE since peaking on March 23rd at 24.8" after the same storm that delivered dust event D5, and peaking some six weeks earlier than the average date for that site of May 5th. Daily average SWE loss at the Wolf Creek Summit Snotel over those 20 days (to April 12), at 0.15" per day, falls short of rates observed in prior water years, as seen in the table below.

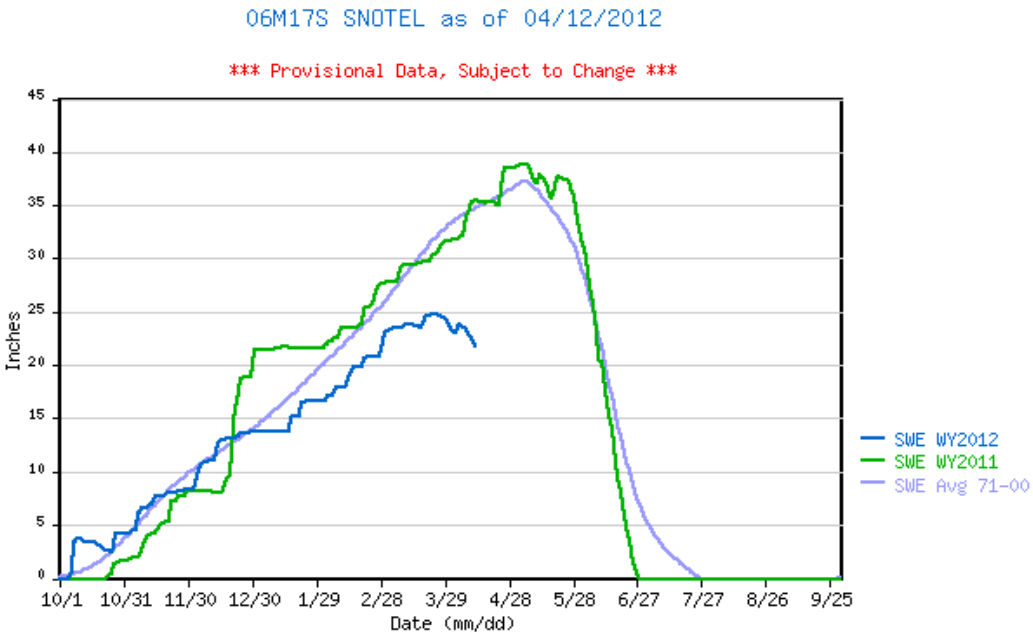
To the north, Peak SWE of 12.0" occurred on/about March 22nd at the Slumgullion Pass Snotel (elev. 11,440'), almost a month earlier than normal. Since Peak SWE, melt rates have been slow at this Snotel. (Small increases in SWE up to 12.4" in late March were reported on days with no precipitation and may reflect rapid settlement of wet snow.)

Located on the Rio Grande main stem, and bracketed between Slumgullion and Wolf Creek passes, the Beartown Snotel station, at 11,600', has lost almost 10" of SWE since peaking on March 21st at 17.1", over a month earlier than normal. At an average daily rate of 0.45" SWE loss, this rate of snowmelt is approaching rates observed in prior years (see table).

Wolf Creek Summit SNOTEL Snowmelt Season Summary Data

	Date Peak SWE	Peak SWE	Days to SAG	Post-Peak Added SWE	Adjusted Daily Mean Loss SWE	Period Mean Temp
WY 2006	5/1/2006	25.7	40	1.2	0.67	7.7
WY 2007	4/26/2007	32.3	59	5.6	0.64	6.5
WY 2008	4/26/2008	47.5	71	3.7	0.72	6.7
WY 2009	5/6/2009	35.9	49	3.5	0.80	7.1
WY 2010	5/5/2010	37.1	44	1.4	0.88	7.1
WY 2011	5/5/2011	38.9	54	4.5	0.80	7.4
Max	5/6	47.5	71	5.6	0.88	7.7
Min	4/26	25.7	40	1.2	0.64	6.5
Range	11	21.8	31	4.4	0.23	1.1

Adjusted Daily Mean Loss SWE rates include additional SWE received after date of Peak SWE



STREAM FLOWS

[*This discussion is current as of Thursday, April 12, 2012*] The Wolf Creek Pass CODOS site offers insight into snowmelt runoff behavior on both sides of the Pass. Streamflow at the Rio Grande at Del Norte gauge have been sustained at levels well above daily median discharge rates since mid-March, surging during the prolonged period of dry, very warm, and sunny weather of late March, with multiple dust layers merged at the snowpack surface. Since our site visit on April 9, a significant surge has driven discharge up to 2,000 cfs at that gauge, almost 4x the median flow for that date, at the same time that dust event D8 has fully emerged in the western San Juan Mountains (Senator Beck Basin is only 18 miles NW of the Beartown Snotel) and with very high temperatures earlier this week.

To the west, streamflow data from the USGS San Juan River at Pagosa Springs gauge show a somewhat less amplified but similar pattern, well above median flows.