INYO COUNTY WATER DEPARTMENT

2012-2013

ANNUAL REPORT

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To protect the County's environment, citizens, and economy from adverse effects caused by activities relating to the extraction and use of water resources and to seek mitigation of any existing or future adverse effects resulting from such activities.

SECTION 1: EXECUTIVE SUMMARY 2012-2013

The 1997 MOU between LADWP, Inyo County, California Department of Wildlife, California State Lands Commission, the Sierra Club, and the Owens Valley Committee requires that "*DWP and the County will prepare an annual report describing environmental conditions in the Owens Valley and studies, projects, and activities conducted under the Los Angeles Agreement and this MOU.*" This requirement has customarily been fulfilled by two reports, one issued by LADWP and one issued by the Water Department. The Water Department's Annual Report is a vehicle for disseminating information about conditions and activities related to the Inyo/Los Angeles Long-Term Water Agreement. The Water Agreement contains a number of provisions for collecting and sharing data, analyzing data, managing groundwater pumping, and mitigating negative effects of LADWP water management. We strive to make this report informative broadly for those wishing an overview of conditions and trends, and also to provide detailed analysis for those desiring to look closely at conditions in Owens Valley. In general, this report covers the 2012-13 runoff year (April 1, 2012 through March 31, 2013), but also contains material pertaining to LADWP's planned pumping for the 2013-14 runoff year. Our Water Agreement-related data collection and analysis falls into three categories: management of LADWP water-related activities through the Inyo/Los Angeles Technical Group and Standing Committee; environmental monitoring to assess impacts of LADWP activities and compliance with Water Agreement goals; and planning, monitoring, implementation, and enhancement of mitigation measures associated with the Water Agreement. This annual report gives the results of these activities.

One area of complete agreement between LADWP and the County is that we need more snow in the Sierra Nevada and rain on the Owens Valley floor. 2012-2013 was dry, and 2013-2014 promises more of the same. LADWP's April 1, 2012 runoff forecast was 65% of normal runoff. Preliminary runoff figures indic ate that runoff for 2012-13 was 57% of normal, somewhat less than was forecast. Runoff for 2013-14 is forecast to be even less, at 54% of normal. The prevailing dry conditions reduce the amount of water available for export to Los Angeles and for use in Owens Valley. During 2012-2013, LADWP reported in-valley uses of 178,250 acre-feet (AF), including 47,800 AF of irrigation, 11,000 AF of stock water, 8,914 AF supplied to enhancement/mitigation projects, 9,100 AF for recreation and wildlife projects, 2,700 AF provided to Indian lands, 20,900 AF for the Lower Owens River Project, and 75,300 AF for dust control at Owens Lake. We anticipate that in-valley uses during 2013-14 will be similar.

During the period October 2011 through September 2012 (the most recent 12-month period that LADWP has reported to the Water Department) LADWP exported 249,008 AF from the eastern Sierra Nevada. LADWP projects that the Los Angeles Aqueduct will deliver 66,986 AF to Los Angeles during 2013-14, the lowest amount in the period 1935 to present.

In the 2012-2013, LADWP pumped 88,681 AF in Owens Valley, slightly more than the 88,000 AF that was planned. Observations of depth to water at permanent monitoring sites and indicator wells show that the water table declined in all wellfields. Declines were also observed at all permanent monitoring sites outside wellfields. Declines were typically in the 1 to 3 foot range, with the highest declines (about 6-7 feet) being in the southern Independence-Oak and northern part of the Symmes-Shepherd wellfield. Comparison of predicted and observed water table changes shows that the Water Department's methods for forecasting water table changes performed reasonably well and as expected.

For 2013-14, because of successive dry years, the annual operations plan developed this April is for the six-month period from April through September 2013, and a second plan will be developed for the period October 2013 through March 2014. For the period April through September 2013, LADWP proposed to pump 47,370 – 54,660 AF. The Water Department analyzed the proposed plan by reviewing existing water levels, projecting how those water levels would change based on various levels of pumping, looking at vegetation conditions, and recommended pumping at the level of 46,825 – 49,585 AF. It is expected the planned levels of pumping will result in pumping for the entire 2013-14 runoff year in the 70,000 – 80,000 AF range. After receipt of the County's comments and discussion at the Technical Group, LADWP finalized their annual operations plan, but it was unchanged from the proposed plan. Under the annual operations plan, we expect that water tables will decline in wellfields around 1 to 2 feet from April, 2013.

The Water Agreement's ON/OFF method of managing LADWP pumping wells is based on monitoring sites where vegetation cover, soil water, and depth to the water table are measured, and the vegetation's water needs are compared to the available soil water. Pumping wells are linked to a monitoring site, and if sufficient soil water is present for vegetation at a site, then wells linked to that site may be pumped. As part of the monitoring effort, each month the Water Department measures depth to water and soil water at 25 monitoring sites in wellfields and 8 sites in control areas (areas unaffected by pumping). At the beginning of 2012-13, eight sites were in ON status. Two additional sites went into OFF status during 2012-13, so currently six sites are in ON status.

Each year the Water Department monitors selected vegetation parcels within the valley to ensure that the Water Agreement's vegetation goals are met. The primary goal of this monitoring, according to the Green Book are to detect any *"significant decreases and changes in Owens Valley vegetation from conditions documented in 1984 to 1987"*. Vegetation live cover and species composition documented during the 1984-87 mapping effort were adopted as the baseline for comparison with each annual reinventory according to the Water Agreement.

The reference measurements collected within individual areas mapped with similar vegetation (parcels) are referred to as 'baseline'. From September 1984 to Nov 1987, LADWP inventoried and mapped vegetation on 2126 vegetation parcels (223,168 acres). Many of these parcels are non-groundwater-dependent plant communities or are distant from pumped areas. In the summer of 2012, the Water Department resampled 110 parcels using the line-point protocol described in the Green Book. The results were analyzed in terms of the condition of individual parcels with respect to baseline, and comparison of pumping-affected parcels (wellfield parcels) to non-pumping-affected parcels (control parcels). Statistical analysis of this data showed that the relative change in perennial cover between baseline and the time period 1992-2012 was statistically different for the wellfield compared to the control parcel group. Cover in the control parcel group was higher than or close to baseline while cover in the wellfield parcel group was generally lower than or close to baseline during 1992-2012. Overall perennial cover and grass cover in 2012 for both wellfield and control parcel groups was significantly below baseline. Within the wellfield parcel group, the relative proportion of shrub cover has significantly increased. Finally at the individual parcel level of analysis, 57% of wellfield parcels were either significantly below their baseline cover values (41%) or had significant increases in shrub cover (16%).

The Water Agreement and 1991 Final Environmental Impact Report include the implementation of over fifty mitigation projects. The Water Department's role in these projects includes implementation of the Saltcedar control program, joint implementation with LADWP of the Lower Owens River Project, development of plans for as-yet unimplemented projects, and monitoring progress of projects that have been implemented. Most of the projects have been implemented. Ongoing challenges are successful revegetation of negatively affected LADWP land and effective adaptive management of the Lower Owens River.

Bob Harrington
Inyo County Water Department Director
June 1, 2013

SECTION 2: DIRECTOR'S REPORT 2012-2013

INYO COUNTY
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The Water Department's efforts during 2012-2013 were directed toward our core mission of assisting in the implementation of the County's water resources policies through the Inyo/Los Angeles Long-Term Water Agreement. Our work consists of four main activities: management of LADWP water-related activities through the Inyo/Los Angeles Technical Group and Standing Committee; environmental monitoring to assess impacts of LADWP activities and compliance with Water Agreement goals; planning, monitoring, implementation, and enhancement of mitigation measures associated with the Water Agreement; and disseminating information and fostering public involvement in County water policy. The results of these activities are reported in this Annual Report.

One of our principal activities during 2012-13 was an ongoing effort to seek mitigation for impacts to vegetation in the Thibaut-Sawmill wellfield in the area southwest of the Black Rock Fish Hatchery. In February 2011, the Water Department presented to the Technical Group an analysis of vegetation conditions in vegetation parcel Blackrock 94. The Water Department requested that the Technical Group examine this question in June, 2009, and LADWP agreed to the evaluation in October, 2009. To progress with this effort, the Technical Group agreed that the Water Department would take the lead in conducting the analysis, and presented its results in a comprehensive report concluding that LADWP activities had resulted in and were continuing to cause negative changes to groundwater-dependent vegetation in the parcel. This effort is an important test of the effectiveness the Water Agreement's provisions for avoiding and mitigating negative impacts due to LADWP water management. Unfortunately, the Technical Group has been unable to agree on a determination of whether a significant impact has occurred, so the County submitted the question to the Standing Committee. LADWP's objection stems from their claim that the Water Department did not follow the procedures of the Water Agreement and Green Book in the analysis presented to the Technical Group. The Standing Committee could not resolve the dispute, so the question of whether the conditions in the parcel require mitigation is proceeding to mediation/temporary arbitration under the Water Agreement's dispute resolution process. The mediation/temporary arbitration process should conclude by October, 2013.

The "Green Book" is the technical appendix to the Water Agreement, which describes the methods and protocols for conducting the measurements and analysis to manage pumping. The Green Book was developed and adopted over twenty years ago, and since then, it has been recognized that managing pumping based on water table conditions would be more effective than the present method based on soil water and vegetation abundance.

The Water Department and LADWP have been trying to revise the "Green Book" since 2007, but the two sides have been unable to agree on appropriate methods. Also, as the dispute over vegetation conditions in the Black Rock area has proceeded, it has become clear that there are disagreements over vegetation monitoring methods. Little progress was made on Green Book revisions during 2012-13 because our efforts were directed at other projects, including resolution of the Black Rock dispute. The Water Department has continued its annual program of monitoring vegetation conditions for the purpose of assessing vegetation conditions relative to the mid-1980s baseline conditions established by the Water Agreement, and continues to develop methods for managing pumping based on water table changes. Looking forward to 2013-14, we have reached agreement with LADWP on a facilitator for our Green Book work, and will convene an expert panel to examine vegetation monitoring methods.

2012-2013 was an active year for mitigation projects:

- LADWP brought a complaint forward that enhancement/mitigation projects were not being supplied with pumped groundwater as was originally planned when the projects were developed in the 1980s. The Standing Committee directed the Technical Group to evaluate enhancement/mitigation projects and report back, and the evaluation is underway.
- A recreational use plan for the Lower Owens River Project was completed in 2013. The next steps for this project will be to seek funding for CEQA analysis of the project and implementation. This culminated a process where input was sought from stakeholders including recreationalists, lessees, tribes, business interests, environmental groups, and government agencies through a series of public meetings, and their concerns were synthesized into a plan that recognizes their combined concerns, as well as recognizing the habitat goals, land uses, and recreational goals of the LORP.
- In March 2012, LADWP met their deadline to construct and implement eight projects using 1,600 acre-feet of water provided through the 1997 MOU. These projects mitigate for loss of spring habitat through a number of strategies, including creation of spring-like habitat by diverting surface water or by providing water from wells, enhancement of existing spring-like habitat from with additional water from flowing wells, and allocating water from the Los Angeles Aqueduct to reduce the need for groundwater pumping to supply recreational uses. LADWP and the Water Department are jointly monitoring these projects.

We maintained an active effort in 2012-13 to engage the public in water policy matters. Public outreach efforts included conduct of numerous public meetings, including six Water Commission meetings, eight Technical Group meetings, and four Standing Committee meetings. Also, we had a well-attended public field trip observe and discuss water management issues and mitigation projects in the Laws wellfield. Our web site is a key means of disseminating information, and we recently concluded an effort to upgrade the site.

The Annual Report is a requirement of the 1997 MOU, so the focus of the Annual Report is on Water Department activities related to the LADWP and the Water Agreement. The Water Department is involved in a number of activities unrelated or indirectly related to the Water Agreement including participation in the Inyo-Mono Integrated Regional Water Management Group, assistance to other County departments needing hydrologic analysis on projects they are working on (e.g., environmental analysis for permitting of solar, industrial, or residential developments), evaluation of Owens Lake dust/water/habitat projects, monitoring and management of projects permitted under the County groundwater ordinance, and development of a County-wide groundwater elevation monitoring network. These activities are not covered in this Annual Report, but information on their status may be found on our web site http://www.inyowater.org.

Finally, our vegetation scientist, Meredith Jabis, resigned in July, 2012 to pursue graduate studies at UC Berkeley. We will miss her expertise, professionalism, and cheery demeanor in the workplace, and wish her success in her future endeavors. Although Meredith worked for the Water Department for only two and a half years, in that short time she introduced new methods and new rigor into how the Water Department analyzes vegetation change. We have recently hired Zachary Nelson, a capable and qualified scientist to fill the position of vegetation scientist at the Water Department.

SECTION 3: PUMPING MANAGEMENT AND GROUNDWATER CONDITIONS

Annual Pumping Plans

LADWP prepares an operations plan each April for the twelve month runoff year beginning April 1st in accordance with the Water Agreement. In the event of two consecutive dry years when actual and forecasted Owens Valley runoff for the April to September period are below normal and average less than 75 percent of normal, LADWP prepares two six-month plans. The 2013-14 runoff year qualifies under the consecutive drought year provisions of the Agreement. The first plan describes operations from April 1 st to September 30th, and the second plan covers the October 1st to March 31st period. The plans are submitted to Inyo County by April 20th and October 20th. Each plan includes projected amounts for runoff, pumping, reservoir storage, water used in the Owens Valley, and water exported to Los Angeles. Also, the plans must comply with the pumping well On/Off provisions of the Agreement based on soil water and vegetation measurements. Inyo County reviews the proposed operations plans which usually includes performing an analysis of the effects of LADWP operations on groundwater levels in the Valley. Following a Technical Group meeting to resolve concerns raised by the County, LADWP finalizes the plans.

2012-13 Pumping Plan

Total pumping within the Owens Valley for 2012-13 was 88,681 acre-feet (ac-ft), which was slightly greater than the 88,000 ac-ft planned (Table 3.1). In most wellfields, actual pumping was within range planned, but in the Symmes-Shepherd wellfield actual pumping was 270 ac-ft above the range planned. Runoff from the Owens River watershed during the 2012-13 runoff year was forecast to be 268,400 ac-ft or 65% of normal. The actual runoff value will be available later in 2013 when the all the surface water measurements that constitute the sum have been tabulated. The effect of pumping and runoff in 2012-13 on water levels in several test wells is discussed below.

The Water Agreement and Green Book include procedures to calculate a pumping limit to prevent groundwater mining to ensure no long term decline in aquifer storage. The mining calculation is a comparison of pumping and recharge for each wellfield on a water year basis (October 1st through September 31st) for a 20 water year period. The 19.5 year total of actual pumping is subtracted from 20 years of estimated recharge to arrive at an estimated April-September pumping limit for each wellfield and Owens Valley as a whole. The estimate of groundwater recharge in the Owens Valley from the mining calculations was approximately 138,482 ac-ft compared to 91,642 ac-ft of pumping for the 2012 water year, and no wellfield was in violation of the groundwater mining provision. For the 2013 water year recharge is preliminarily estimated to be 106,636 ac-ft and planned pumping in wellfields is not expected to violate the groundwater mining provision.

LADWP prepares an operations plan each April for the twelve month runoff year beginning April 1st in accordance with the Water Agreement.

Table 3.1. LADWP actual pumping by wellfield for the 2012-13 runoff-year, and planned pumping for the first six months of 2013-14. Estimated planned pumping minimum and maximum for the entire 2013-14 runoff-year as well as absolute minimum pumping prepared by Inyo County to analyze the annual effect on water levels are also included.

Wellfield	Actual Pumping 2012-13 (ac-ft)	Planned Pumping for Apr-Sept. 2013-2014 (ac-ft)	Minimum Inyo Estimate for 2013-14 (ac-ft)	Maximum Inyo Estimate for 2013-14 (ac-ft)	Estimated Minimum Pumping (ac-ft)
Laws	6,990	5,760-7,200	6,460	7,900	6,460
Bishop	11,491	9,000	11,103	11,103	10,600
Big Pine	26,451	11,550-12,900	24,347	25,697	20,500
Taboose-Aberdeen	12,734	4,200-7,380	4,540	7,720	300
Thibaut-Sawmill	12,520	6,600	13,200	13,200	12,000
Ind.-Oak	8,816	5,280-6,600	5,710	7,030	5,710
Symmes-Shepherd	7,270	3,100	3,175	3,175	1,200
Bairs-Georges	1,678	1,320	1,420	1,420	500
Lone Pine	731	560	755	755	720
Total	88,681	47,370-54,660	70,710†	78,000	57,990†

†: Value includes the proposed reduction in irrigation and associated pumping for the Laws and Independence-Oak wellfields. LADWP's proposal decreases pumping by approximately 2,760 ac-ft.

Evaluation of 2012 DTW predictions

The Water Department routinely uses linear regression models to predict the effects of pumping on depth to water table (DTW) as part of its analysis of LADWP's annual operations plans. Periodically, we examine the accuracy of our models by comparing the predictions with DTW measurements collected the following year on April 1. The regression models were constructed from historical data for wellfield pumping, Owens Valley runoff, and current water levels. The models in Laws rely on an estimate of the diversions into the McNally canals instead of Owens Valley runoff as the variable related to groundwater recharge. For twelve permanent monitoring sites, a second model is used that relies on predicted DTW in a nearby indicator well that responds similarly to pumping and runoff. The models were originally developed by Harrington (1998) and Steinwand and Harrington (2003) and have been updated annually. These reports are available on the Water Department website. At one site, SS2, the monitoring well was dry in 2013 preventing the comparison of predicted and measured change in water levels. Predictions for the other 44 wells made in 2012 were examined for this report.

The predicted DTW values were based on the high pumping amount planned by LADWP in the 2012-13 pumping plan. Actual and modeled pumping in 2012-13 differed by as much as 2000 ac-ft in Big Pine, but usually the pumping totals were within a few hundred acre-ft. Also, preliminary data from LADWP suggest the forecasted runoff overestimated actual runoff.

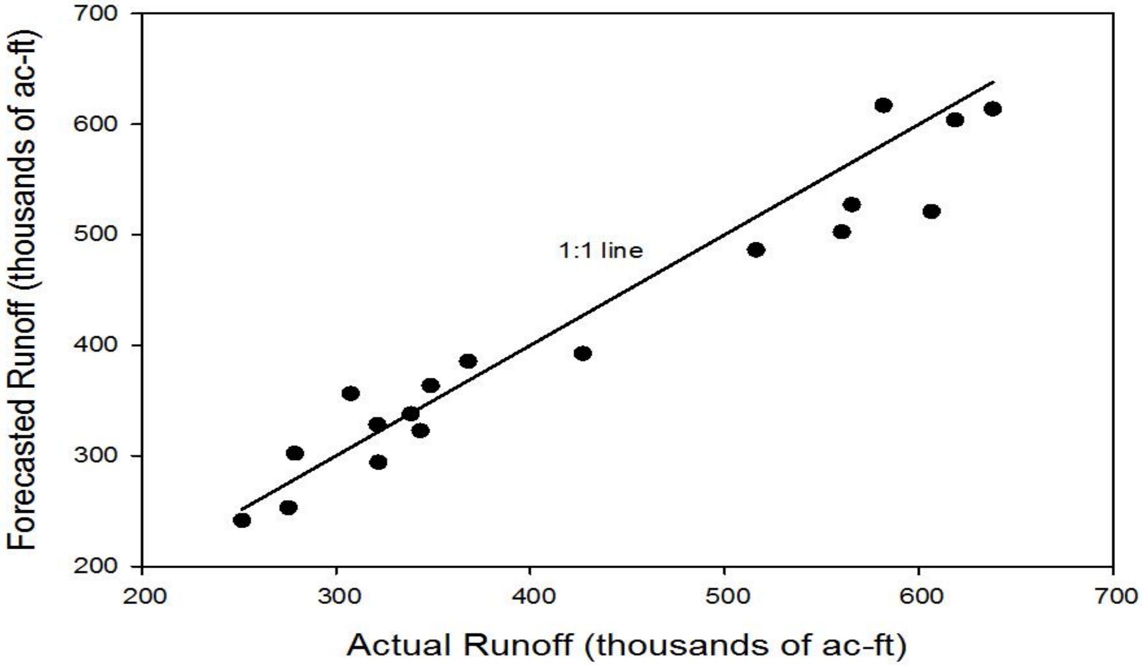

Figure 3.1. Comparison of actual and forecasted runoff since 1994. During this period, LADWP has revised the method to forecast runoff, but there was no discernible trend (better or worse) in the accuracy of the forecasts over time.

The LADWP runoff forecast tracks actual runoff well (Figure 3.1), but may underpredict runoff when conditions are above average (actual runoff exceeded the forecasted amount only in 2011-12). This analysis of the predictions includes uncertainty in the input variables (runoff forecast and planned pumping) as well as uncertainty in the models. Model uncertainty includes all management actions and environmental conditions not captured in the regression model e.g. atypical recharge or pumping operations near one of the test wells. No attempt was made to revise the 2012 predictions based on actual runoff and wellfield pumping amounts to account for that source of uncertainty.

Model performance in 2012-13 was slightly better than in 2011-12. Measured and predicted change in DTW are plotted in Figure 3.2. If the models were perfect predictors, the points would fall on the 1:1 linbetween the lower left and upper right quadrants. All but one point was in the correct quadrant, suggesting the direction of change (rise or decline) was nearly always correctly predicted. The average deviation (actual value) for all wells was slightly negative (-0.25 ft) suggesting a slight tendency in 2012 to predict smaller watertable declines than were observed. The average absolute deviation was 0.77 ft. Of the 44 wells, actual and predicted DTW in 28 wells differed by less than 1 ft, and 39 differed by less than 1.5 ft.

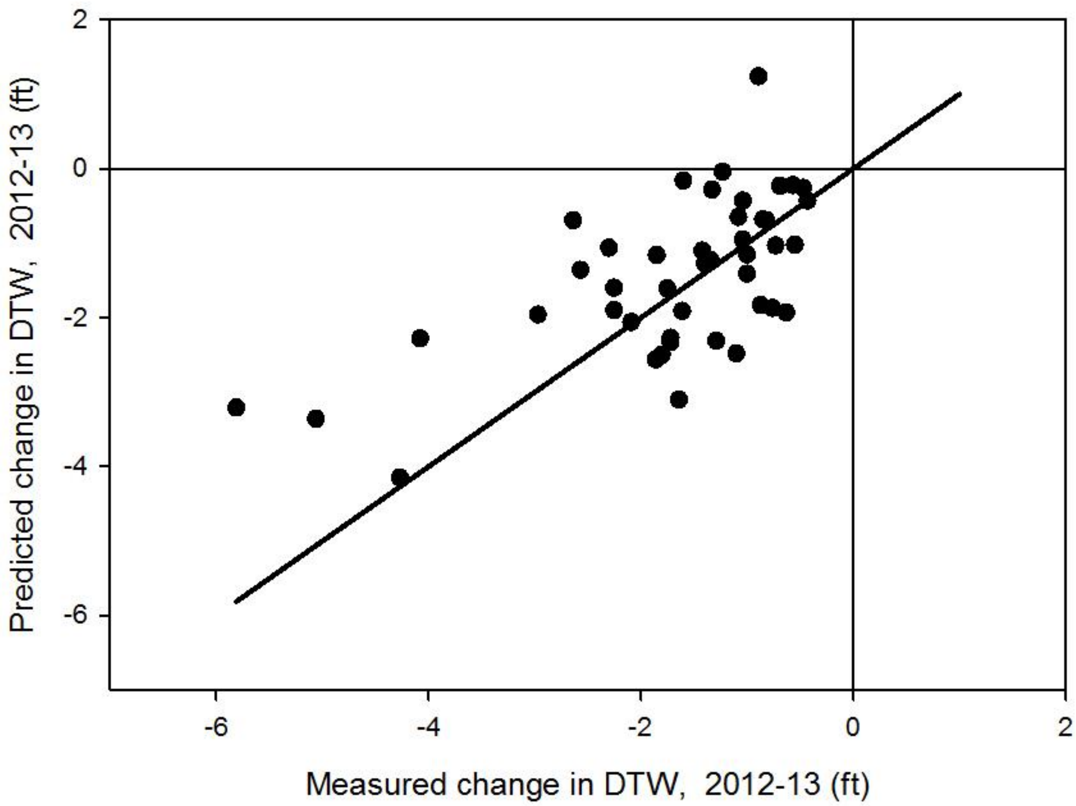

Figure 3.2. Measured and predicted change in DTW from April 2012 to April 2013 for 44 indicator wells and monitoring site wells. The solid line is the 1:1 line. Negative values denote a decline in water level.

Predictions were substantially in error for five wells: 574T (Laws), 407T and 409T (Independence-Oak), 447T and V009G (Symmes-Shepherd). For these wells, the watertable declined more than predicted. DTW in V009G is predicted from 447T, and thus the two are not independent. Pumping in the Symmes-Shepherd wellfield in 2012 primarily occurred from production wells located near 447T. The regression models rely on wellfield pumping totals, and localized pumping near a particular indicator well can cause the predictions to underestimate drawdown.

As mentioned previously, for eleven wells, two regression models were used sequentially to predict DTW which introduced an additional source of uncertainty in predictions for those wells. The average absolute deviation for the predictions based on one model and two models were 0.71 ft and 0.94 ft, respectively. Given the similar accuracy of the two sets of wells, relying on the paired regressions was not a large source of additional uncertainty.

2013-14 Pumping Plan

LADWP issued a first half of the year operations plan for the 2013-14 runoff year in late May, 2013. Forecasted runoff for the Owens River watershed was much below normal at 220,900 ac-ft (54% of normal). LADWP's plan provided a range of planned pumping for four wellfields for the first six

Table 3.2. Predicted water level changes at indicator wells and monitoring sites for estimated amounts of LADWP's annual pumping for 2013 and estimated minimum pumping required for sole source uses. Negative DTW values denote a decline. Baseline is the average of April water levels in 1985-87.

Wellfield, Well Number and Monitoring site	Predicted change in DTW: 78,000 ac-ft	Predicted change in DTW: 70,710 ac-ft	Predicted change in DTW: 57,990 ac-ft	2014 Predicted dev. from baseline: 78,000 ac-ft†
	(ft)	(ft)	(ft)	(ft)
Laws				
107T	0.37	0.87	0.87	-9.29
436T	-0.26	-0.04	-0.04	-4.49
438T	-0.12	0.06	0.06	-5.73
490T	-0.96	-0.87	-0.87	-2.64
492T	-1.75	-0.98	-0.98	-3.88
795T, LW1	0.75	1.04	1.04	-10.82
V001G, LW2	-1.60	-1.18	-1.18	-7.48
574T	0.90	0.96	0.96	-1.86
Big Pine				
425T	-1.60	-1.37	-0.74	-6.92
426T	-1.10	-0.96	-0.60	-4.63
469T	-0.54	-0.40	-0.02	-3.19
572T	-0.81	-0.56	0.16	-4.26
798T, BP1	-1.45	-1.24	-0.64	-3.55
799T, BP2	-0.79	-0.65	-0.26	-3.29
567T, BP3	-1.74	-1.55	-1.00	-7.71
800T, BP4	-1.07	-0.87	-0.29	-6.28
Taboose- Aberdeen				
417T	-1.07	-0.30	0.71	-6.94
418T	-0.55	-0.20	0.26	-1.97
419T, TA1	-1.23	-0.39	0.72	-3.16
421T	-1.06	-0.21	0.92	-4.85
502T	-0.20	0.20	0.72	-4.61
504T	-1.31	-0.27	1.11	-3.33
505T	-0.99	-0.21	0.84	-6.93
803T, TA6	-1.16	-0.40	0.62	-6.94
586T, TA4	-0.63	0.07	1.01	-2.42
801T, TA5	0.41	0.61	0.88	-0.10
Thibaut- Sawmill				
415T	-1.09	-1.09	-0.36	-5.40
507T	-0.12	-0.12	0.08	-0.55
806T, TS2	-2.16	-2.16	-1.78	-2.82
Ind. -Oak				
406T	-0.11	0.04	0.04	-1.42
407T	0.73	1.17	1.17	-6.54
408T	0.19	0.49	0.49	-2.21
409T	1.89	2.99	2.99	-9.37

Wellfield, Well Number and Monitoring site	Predicted change in DTW: 78,000 ac-ft	Predicted change in DTW: 70,710 ac-ft	Predicted change in DTW: 57,990 ac-ft	2014 Predicted dev. from baseline: 78,000 ac-ft†
546T	-0.58	-0.37	-0.37	-5.60
809T, IO1	-2.39	-2.06	-2.06	-9.02
Symmes- Shepherd				
402T	-0.16	-0.16	0.07	-3.31
403T	-0.13	-0.13	0.49	-3.12
404T	0.34	0.34	0.58	-2.53
510T	0.33	0.33	0.55	-2.30
511T	0.36	0.36	0.60	-3.74
447T	-0.08	-0.08	1.35	-22.75
646T, SS2	NA	NA	NA	NA
V009G, SS1	-0.63	-0.63	0.62	-19.37
Bairs- George				
398T	-0.14	-0.14	1.04	-1.06
400T	0.16	0.16	0.38	-0.47

†: Values in this table are only significant to 0.1 ft. Extra digits are presented for transparency before rounding.

months; the range between the lower and upper limit was up to several thousand acre-feet in some cases (Table 3.1). Projected total pumping for the entire runoff year of 2013-2014 is estimated to be inthe low to high seventy thousand acre-feet range depending on groundwater uses in some wellfields. The annual planned pumping will not be known with certainty until the second pumping plan is released in October 2013.

The Water Department analyzed the effect of the operations plan on groundwater levels in the valley using regression models for several monitoring wells (Table 3.2). Most models rely on measured depth to water in April 2013, planned wellfield pumping for the total runoff year (which in this case must be estimated, see Table 3.1), and Owens Valley runoff to predict water levels next April. For several wells, Owens Valley runoff was not a statistically significant variable in the regression model. Water levels in those wells are correlated with pumping, and the models are still useful for evaluating the pumping plan. Also, models in Laws use the amount of water diverted from the Owens River into the McNally canals as the variable associated with recharge. The quantity of water diverted into the McNally canals was estimated from LADWP's annual estimated spreading in Laws provided in Chapter 3 of their 2013 annual report. No spreading is planned for 2013-14 which is not unusual given the low runoff forecast.

The models used by the Water Department to analyze the annual operations plan predict water levels one year in the future (e.g. April 2013 to 2014) based on annual pumping for each wellfield. The models cannot be used to analyze changes over a shorter period. However, the information provided in the pumping plan and LADWP correspondence allowed the Water Department to estimate annual pumping with sufficient accuracy to apply the models. LADWP's proposed pumping for April-September ranges between 43,370 and 54,660 ac-ft. LADWP also suggested that

Table 3.3. Inyo County Water Department recommended pumping and LADWP proposed pumping for the first half of runoff year 2013.

Wellfield	2013 April-September LADWP Proposed Pumping (ac-ft)	2013 April-September ICWD Recommended Pumping (ac-ft)
Laws	5,760-7,200	5,760-7,200
Bishop	9,000	9,000
Big Pine	11,550-12,900	10,800
Taboose-Aberdeen	4,200-7,380	5,200
Thibaut-Sawmill	6,660	6,600
Independence-Oak	5,280-6,600	5,280-6,600
Symmes-Shepherd	3,100	2,305
Bairs-Georges	1,320	1,320
Lone Pine	560	560
Total	47,370-54,660	46,825-49,585

the maximum pumping for 2013-14 will be in the high 70,000 ac-ft range. Minimum pumping for necessary uses during the fall and winter months is approximately 20,300 ac-ft. The sum of the high range of proposed summer pumping and the minimum pumping during the winter is approximately 75,000 ac-ft, nearly the annual total anticipated by LADWP. The Water Department chose 78,000 ac-ft of annual pumping to represent the high range mentioned in the correspondence. Winter pumping needed to bring the annual total to that value is 23,340 ac-ft, just 3,000 ac-ft above the minimum. That amount of pumping is small enough to make reasonable assumptions on how to distribute among wellfields based on recent operations. If the annual total were larger, the required assumptions would not justify continuing with the analysis.

Pumping in excess of the minimum during the winter was distributed between the Laws, Big Pine, and Tabooose-Aberdeen wellfields. The estimated winter pumping amounts were added to the proposed high and low ranges of pumping provided in the DWP plan to derive the annual estimates for the modelling analysis (Table 3.3). The actual pumping distribution will differ, but the assumptions are reasonable enough to use the models to evaluate LADWP's proposal.

Given the relatively low runoff and uncertainty over the pumping amounts, the Water Department recommended pumping in wellfields be minimum to supply uses and protect the vegetation or be limited to amounts that maintain or limit declines to less than 1 foot (near the lower limit in Table 3.3). Two amounts are included for pumping in the Laws and Independence-Oak wellfields because LADWP requested reduced pumping for irrigation which is subject to the Inyo Board of Supervisors approval. The Board did not approve the reduction in irrigation, and pumping in those wellfields will approximate the higher proposed value. The draft and final operations plans and recommendations provided by Inyo County are available from the Water Department.

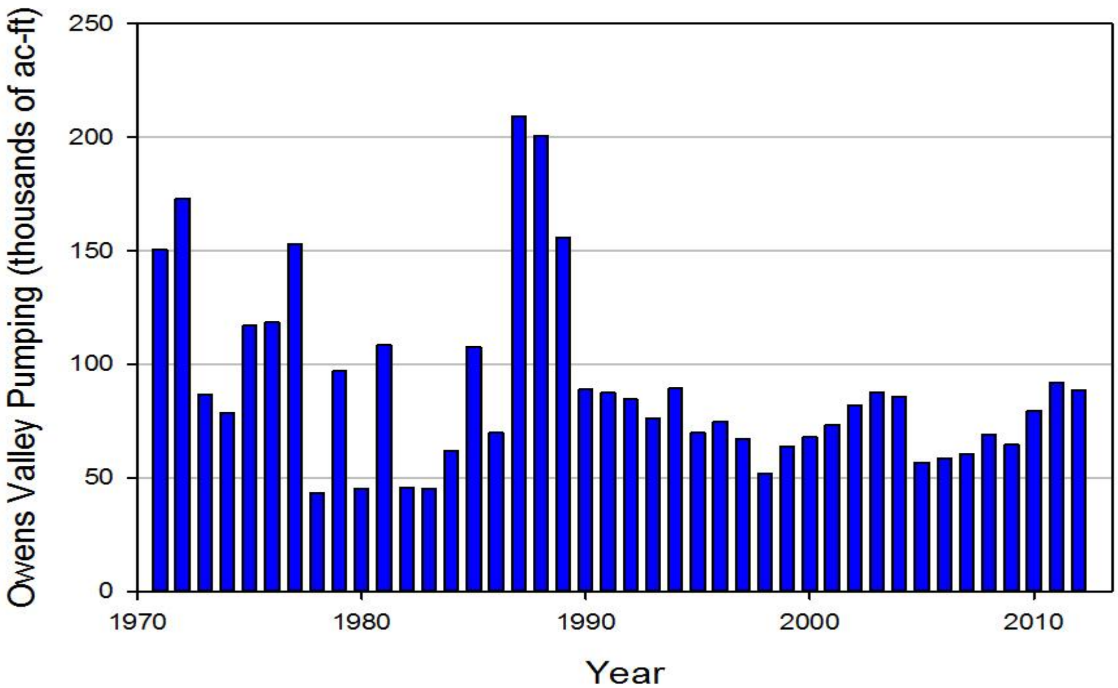

Figure 3.3. Total LADWP pumping in the Owens Valley since 1970. Values are for the runoff year (e.g. runoff year 2011 includes pumping from April 2011 through March 2012).

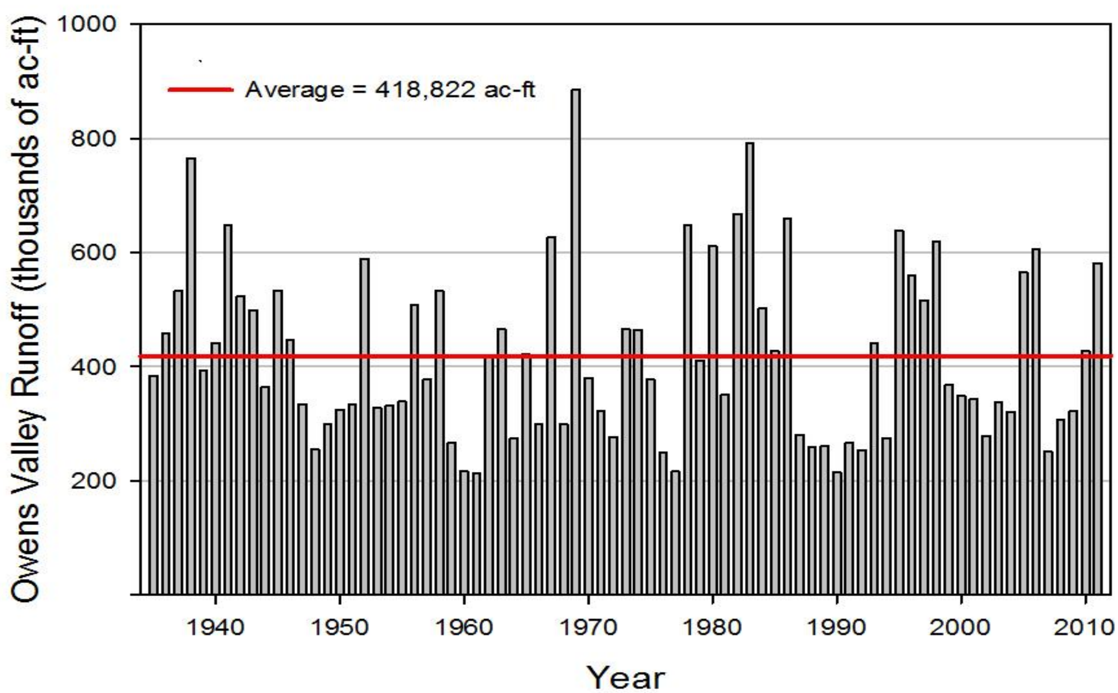

Figure 3.4. Measured Owens Valley runoff since 1935.

Table 3.4. Depth to Water (DTW) at indicator wells, April 2013. All data are in feet. A negative change from April 2012 indicates a water table decline; negative deviation from baseline indicates the water table is below baseline. Depths are from reference point on the test well. Baseline elevation at monitoring sites was predicted from monitoring site/indicator wells regression models unless the test well was present 1985-87.

Wellfield, Well Number and Monitoring site	DTW, April 2013	Change from April 2012	Deviation from Baseline in 2013††
Laws			
107T	33.93	-1.23	-9.66
436T	12.33	-1.08	-4.23
438T	15.21	-2.57	-5.61
490T	14.74	-2.25	-1.67
492T	34.93	-0.76	-2.13
795T, LW1	26.14	-2.30	-11.58
V001G, LW2	25.51	-0.55	-5.88
574T, LW3†	15.97	-0.89	-2.75
Big Pine			
425T	20.22	-1.61	-5.32
426T	15.10	-1.40	-3.53
469T	24.32	-1.04	-2.65
572T	15.35	-1.75	-3.45
798T, BP1	18.23	-1.80	-2.10
799T, BP2	20.87	-1.00	-2.50
567T, BP3	19.94	-2.09	-5.97
800T, BP4	18.75	-1.34	-5.21
Taboose-Aberdeen			
417T	32.84	-1.72	-5.87
418T	9.66	-0.73	-1.43
419T	8.57	-1.10	-1.94
421T	38.14	-1.86	-3.79
502T	11.9	-1.42	-4.41
504T	12.79	-1.64	-2.02
505T	24.54	-1.72	-5.94
586T, TA4	10.09	-1.29	-1.80
801T, TA5	16.17	-0.87	-0.51
803T, TA6	14.21	-1.60	-5.78
Thibaut-Sawmill			
415T	22.80	-1.85	-4.30
507T	5.10	-0.47	-0.43
806T, TS2	13.10	-0.63	-0.66
Independence-Oak			

Wellfield, Well Number and Monitoring site	DTW, April 2013	Change from April 2012	Deviation from Baseline in 2013††
406T	2.88	-0.85	-1.31
407T	14.57	-2.64	-7.27
408T	5.53	-0.43	-2.40
409T	12.86	-4.08	-11.26
546T	8.45	-2.97	-5.02
809T, IO1	12.56	-4.27	-6.63
Symmes- Shepherd			
402T	11.18	-0.82	-3.15
403T	8.32	-1.00	-2.99
404T	6.44	-0.69	-2.87
447T	44.53	-5.81	-22.66
510T	7.63	-0.57	-2.63
511T	8.73	-1.33	-4.10
V009G, SS1	24.70	-5.06	-18.74
646T, SS2	Dry	NA	NA
Bairs-George			
398T	7.27	-2.25	-0.92
400T	6.93	-1.04	-0.63

†: The new test well at LW3, 840T, tracks 574T except during active spreading on the site, and depth to water is on average 1.23ft deeper. ††: Values in this column are only significant to 0.1 ft. Extra digits are presented for transparency before rounding.

Summary of Hydrologic Conditions

The history of Owens Valley pumping and runoff are presented in Figures 3.3 and 3.4. The much below normal runoff in 2012-13 (65% of normal), and the slightly decreased pumping compared to the previous runoff year, resulted in declines in DTW in all indicator wells and monitoring sites (Table 3.4) ranging from 0.43 to 5.81 feet. Water levels declined more than 4 ft in four wells, two in the Independence-Oak (809T and 409T) and two in the Symmes-Shepherd (V009g and 447T) wellfields. Water levels remain below the levels of the mid-1980’s (average 1985-87). Hydrographs for the indicator wells are provided in following discussions of conditions in each wellfield; hydrographs for the permanent monitoring sites are included in the Soil Water section of this annual report. All data presented in the hydrographs are DTW below the ground surface.

Laws Wellfield

In the 1970’s and 80’s, pumping and groundwater recharge in Laws varied greatly year to year causing large fluctuations in the water table (Figures 3.5 and 3.6). This was especially true for 107T and 492T because of their proximity to the McNally canals and LADWP pumping wells. Heavy pumping and low recharge in the late 1980’s caused severe declines in the water table in Laws. Under the Water

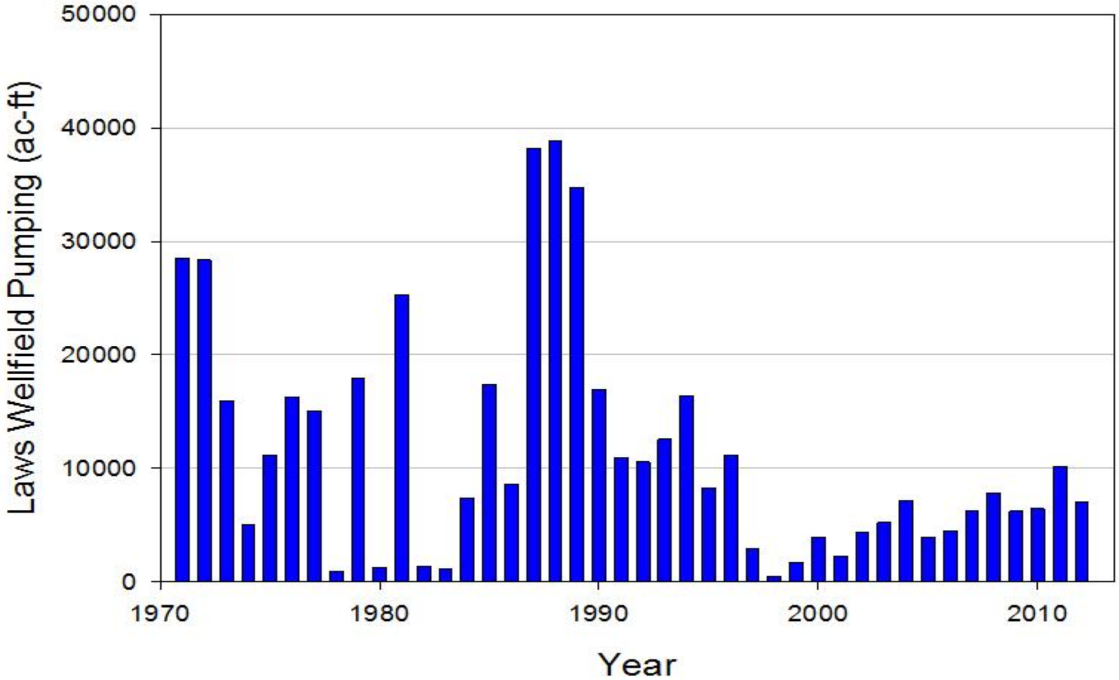

Figure 3.5. Pumping totals for the Laws Wellfield.

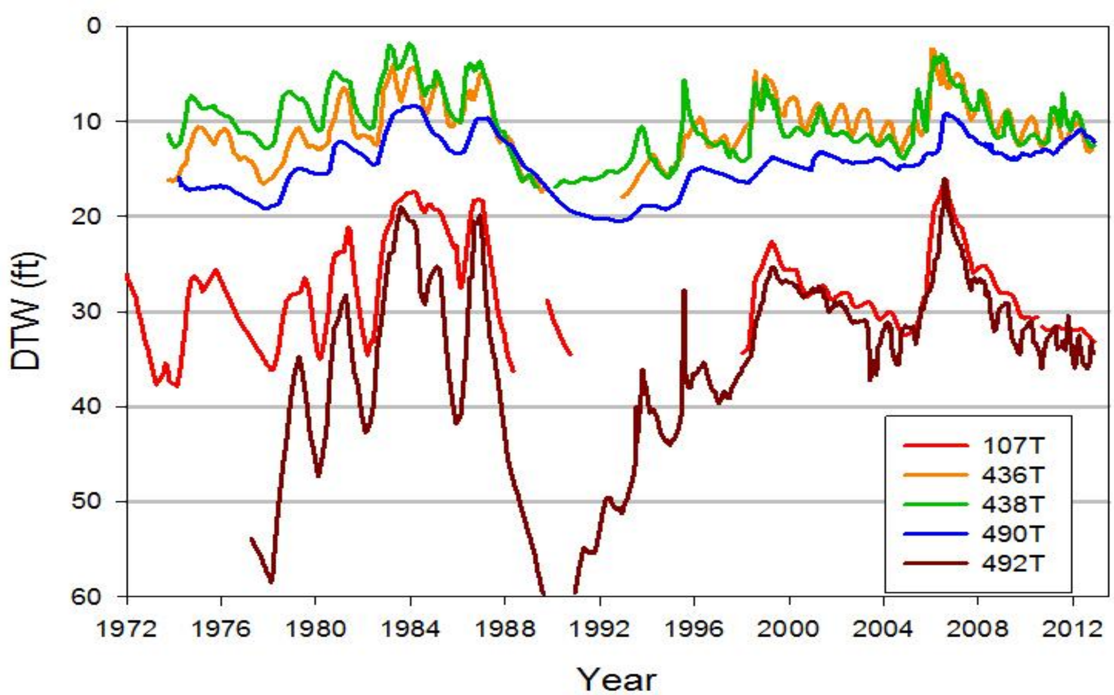

Figure 3.6. Hydrographs of indicator wells in the Laws Wellfield. Well 492T is dry if DTW is below 60 ft. Missing data for well 107T reflect periods when the well was dry.

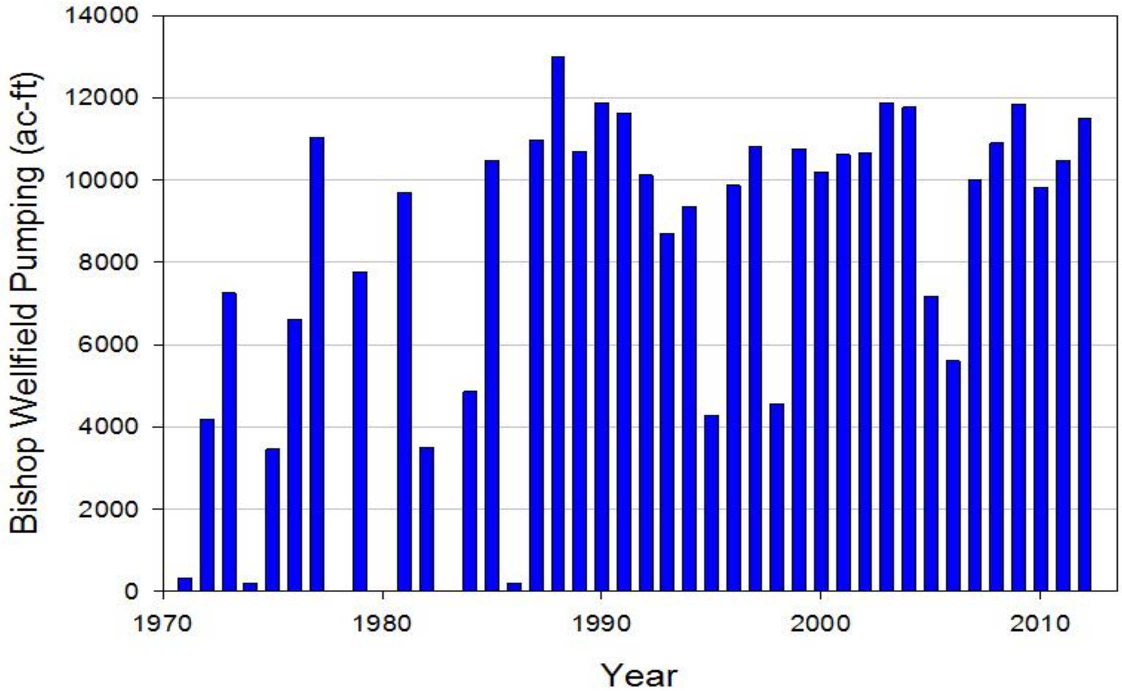

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Figure 3.7. Pumping totals for the Bishop Wellfield.

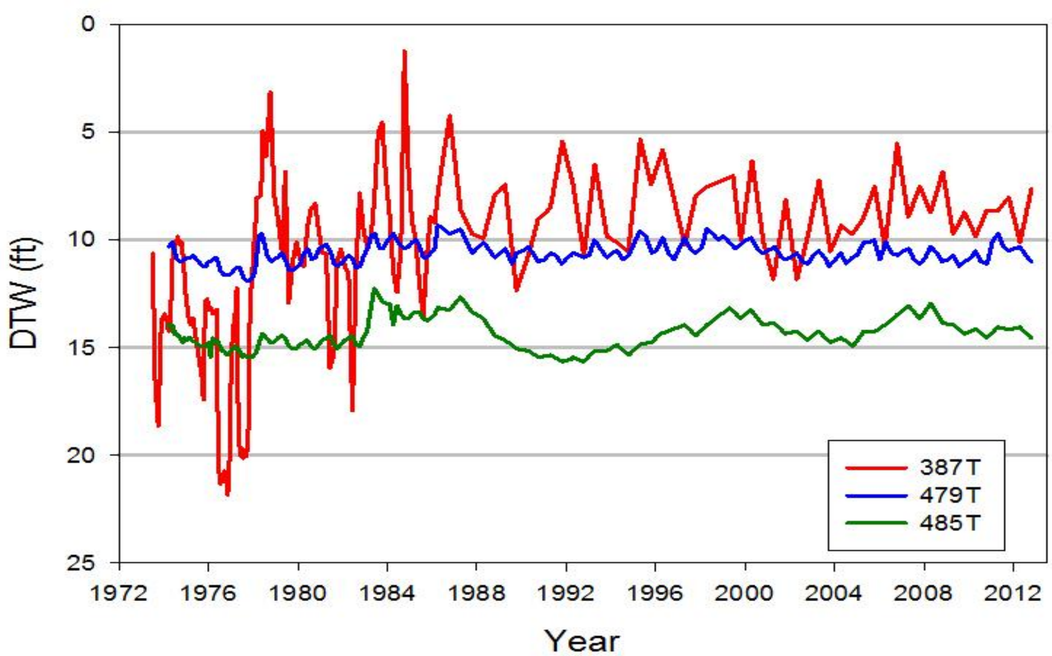


Figure 3.8. Hydrographs of selected monitoring wells in the Bishop Wellfield.

Agreement pumping has remained well below the maximum wellfield capacity. As a result, water levels rose, and beginning in 2000, water table fluctuations have been largely driven by pumping for uses in the wellfield and by water spreading in 2005 and 2006. In 2012-13 DTW declined in all test holes, and all test holes were below baseline water levels in April 2013 (Table 3.4)

Bishop Wellfield

Pumping in the Bishop Wellfield also called the Bishop Cone has been relatively constant for the past 25 years except in years with above normal runoff when pumping decreased, for example 2005 and 2006 (Figure 3.7). The Water Agreement requires the Technical Group to prepare an annual audit of pumping and uses on the Bishop Cone to demonstrate compliance with the Hillside Decree. The Hillside Decree is a 1940 Inyo County Superior Court stipulation and order under which LADWP pumping and water from uncapped flowing wells cannot exceed the annual total of water used on LADWP owned land in the Bishop area. The most recent Bishop Cone Audit examined conditions for the 2010-11 runoff year. Total water extraction on the Bishop Cone was 14,727 ac-ft compared with 25,764.9 ac-ft of recorded uses. The 2011-12 audit has yet to be finalized and remains in draft format.

Because of the Hillside Decree and relatively constant pumping, we do not routinely use indicator wells to analyze the annual operations plan for this wellfield. The three wells in Figure 3.8 are located near the locus of pumping and irrigation adjacent to the city of Bishop (387T) and at intermediate (485T) and larger (479T) distances from the city. Constant pumping as well as recharge from Bishop Creek and the extensive network of canals and ditches to supply irrigated lands produce relatively stable water levels in the Bishop Cone Wellfield. (Figure 3.8).

Big Pine Wellfield

Pumping in the Big Pine Wellfield since 1974 has been relatively large compared with other wellfields (Figure 3.9). Minimum pumping to supply uses in this wellfield include the Fish Springs Hatchery (approximately 19,500 ac-ft) and Big Pine town supply (500 ac-ft). Pumping under the Water Agreement largely has been to supply these uses. In 2009 through 2012 wellfield pumping increased significantly above the minimum. The increase in pumping was primarily for aqueduct supply although it should be noted that most of the hatchery pumped water also reaches the aqueduct. With the increase in export pumping, DTW in three of four indicator wells during the last two years has begun a decline (Figure 3.10) although DTW remains much above the severe decline in the early 1990's and the more recent period of decline ending in 2005. Well 572T is located to the north of hatchery pumping and remains relatively stable. Groundwater levels in 2012-2013 declined 1.0-2.09 ft in all wells. All wells remain below baseline levels in April 2013, usually by more than 2-3 ft (Table 3.4).

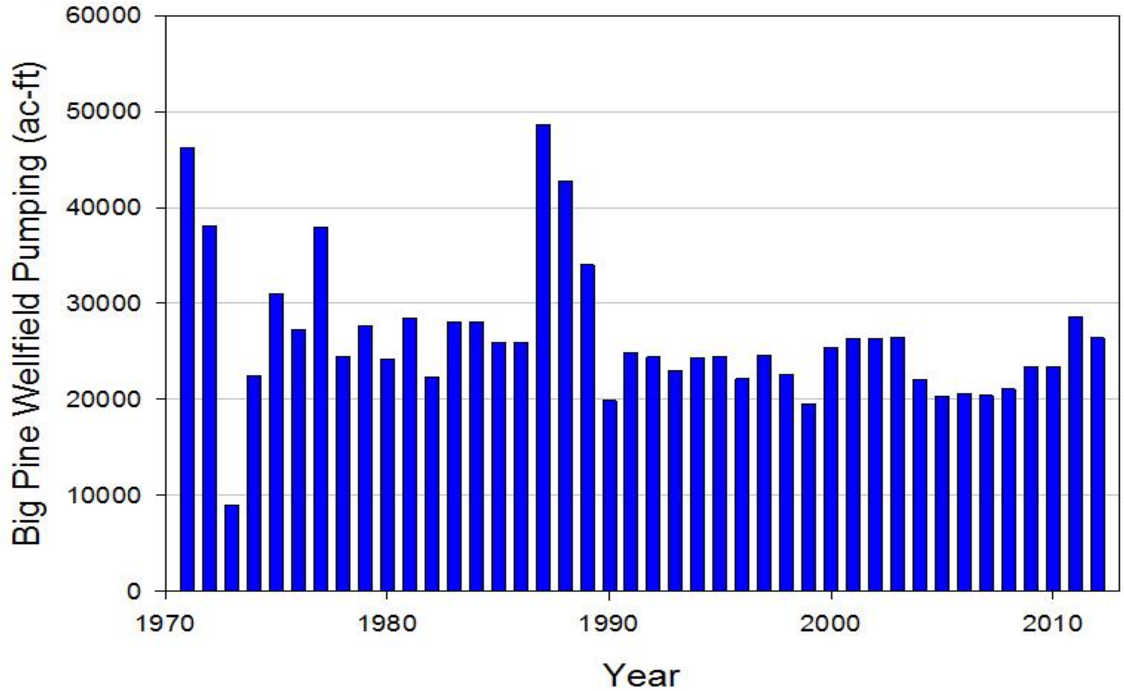


Figure 3.9. Pumping totals for the Big Pine Wellfield.

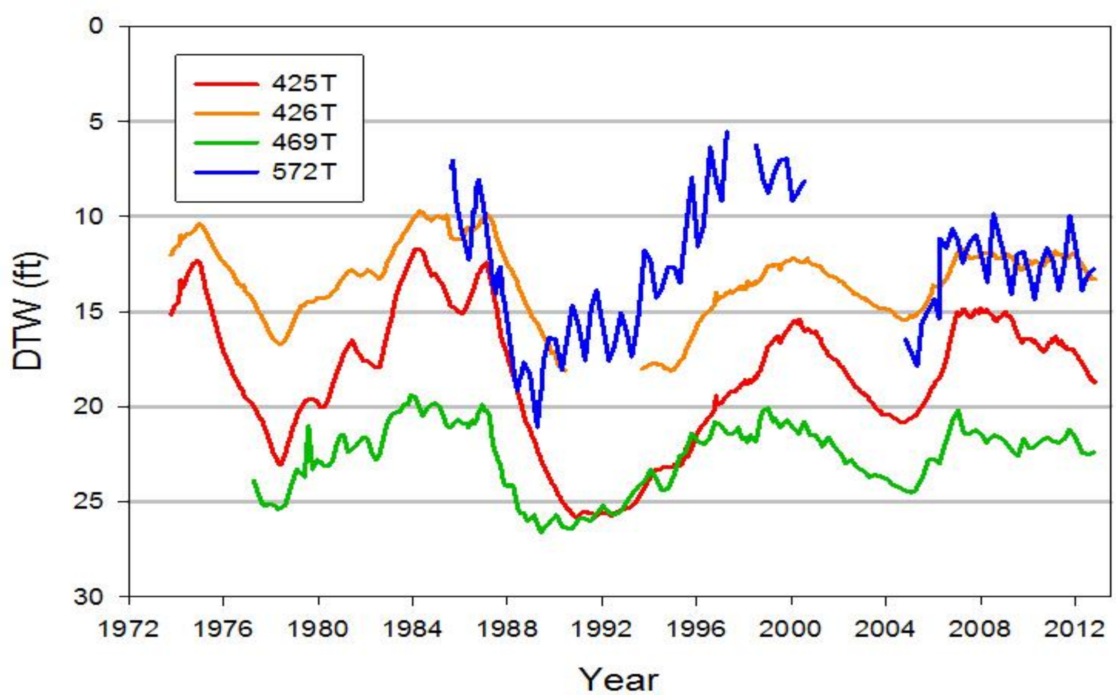


Figure 3.10. Hydrographs of indicator wells in the Big Pine Wellfield. Periods of missing data for 572T occurred when the well was plugged and in need of repair.

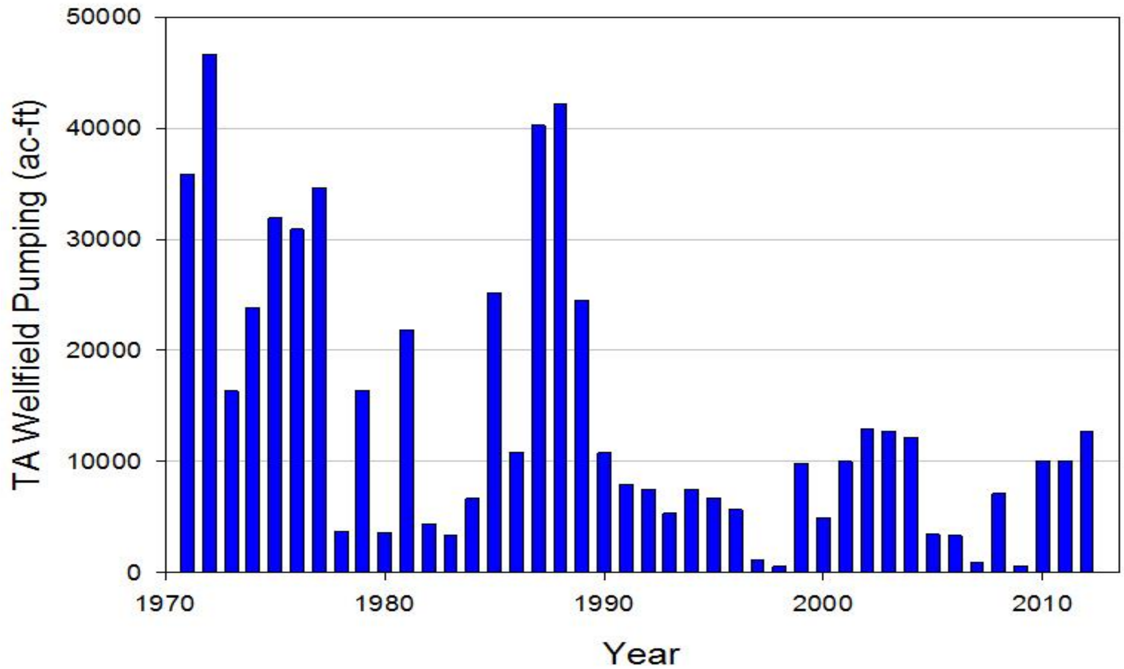


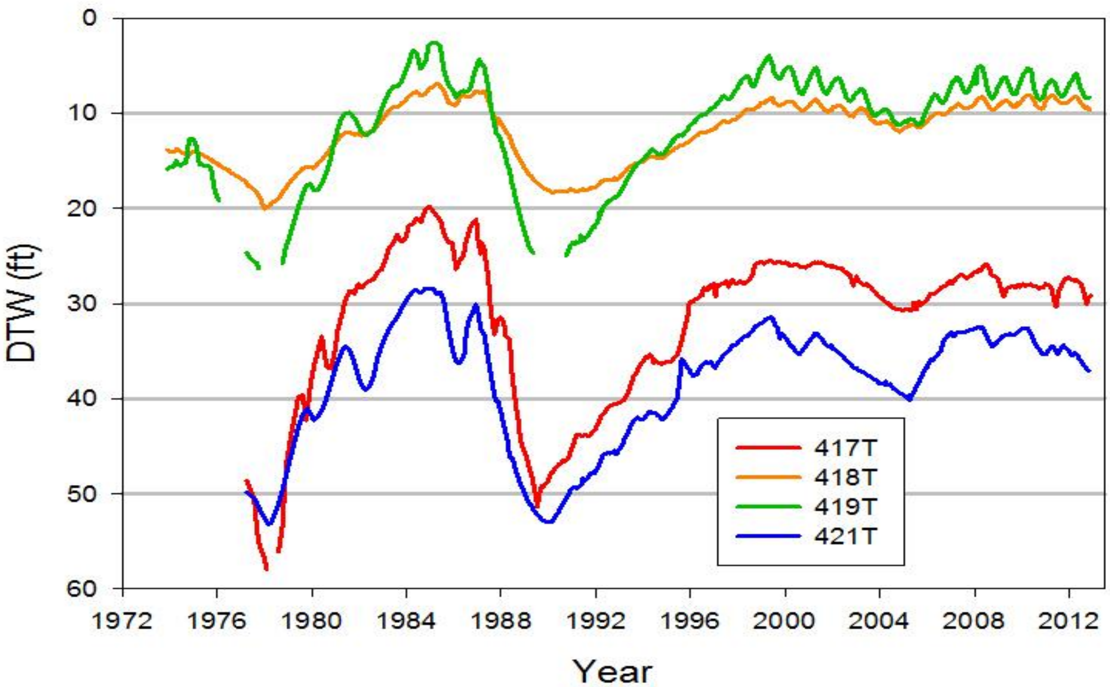
Figure 3.11. Pumping totals for the Taboose-Aberdeen Wellfield.

Taboose-Aberdeen Wellfield

Pumping in the Taboose-Aberdeen Wellfield since 1990 under the Water Agreement has remained much below the wellfield capacity (Figure 3.11). Minimum pumping for this wellfield is approximately 300 ac-ft to supply one mitigation project , and nearly all of the pumping in 2012-13 (12,734 ac-ft) was for aqueduct supply. Hydrographs for the indicator wells exhibit expected response to fluctuations in pumping and runoff (Figure 3.12). Most of the recent pumping has been from wells 349W and 118W. Despite the above normal runoff during 2010 and 2011, pumping also increased, and water levels were stable or declined slightly. In 2012-13, pumping increased and runoff declined greatly and groundwater levels declined in all monitoring wells. Depth to water in all wells was below baseline in April 2013 (Table 3.4).

Thibaut-Sawmill Wellfield

Historically, most pumping in the Thibaut-Sawmill Wellfield has been to supply approximately 12,200 ac-ft annually to the Blackrock Fish Hatchery (Figure 3.13). In 2011-12, total pumping was 14,064 ac-ft including approximately 1,800 ac-ft pumped from this wellfield for aqueduct supply. In 2012-13 total wellfield pumping was 12,520 ac-ft. The four monitoring wells used to track water levels in Thibaut-Sawmill exhibit differing patterns due to local water management within the wellfield (Figure 3.14). Wells 413T and 414T are not used as indicator wells, but they are included as examples from the southern portion of the wellfield. Both wells respond to spreading during high runoff years (e.g. 2006) and then decline gradually in response to pumping and reduced runoff. The overall trend in these wells has been stable or slightly increasing since the late 1990’s. Recently, the trend downward has increased due to low runoff.



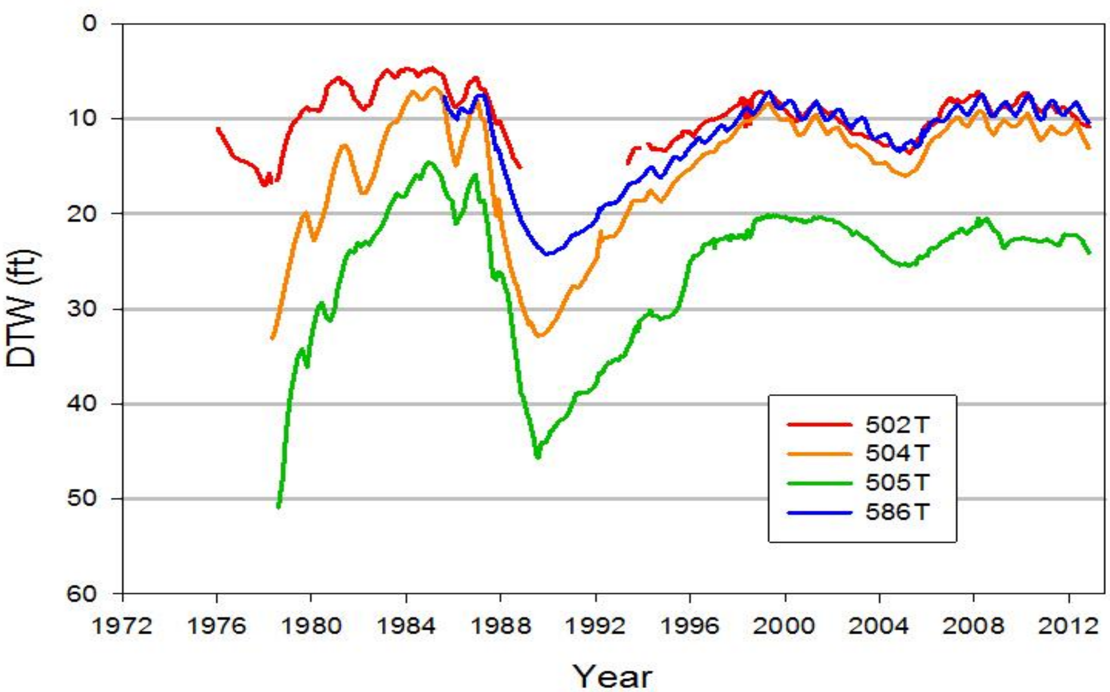


Figure 3.12. Hydrographs of indicator wells in the Taboose-Aberdeen Wellfield. Periods of missing data denote when the well was dry.

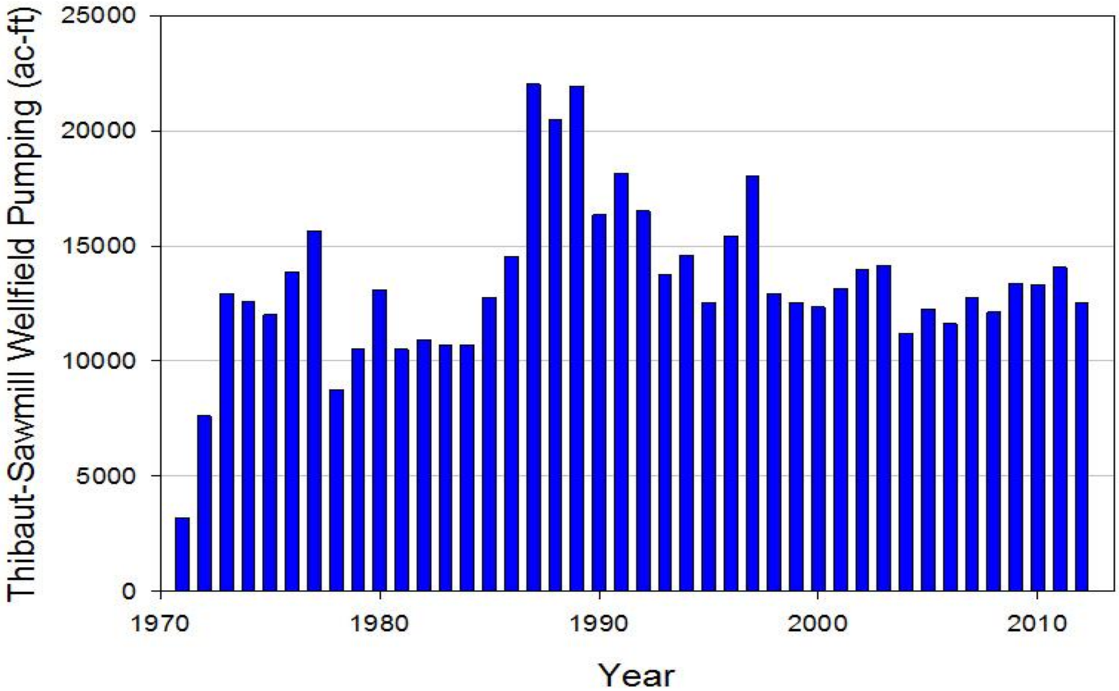


Figure 3.13. Pumping totals for the Thibaut-Sawmill Wellfield

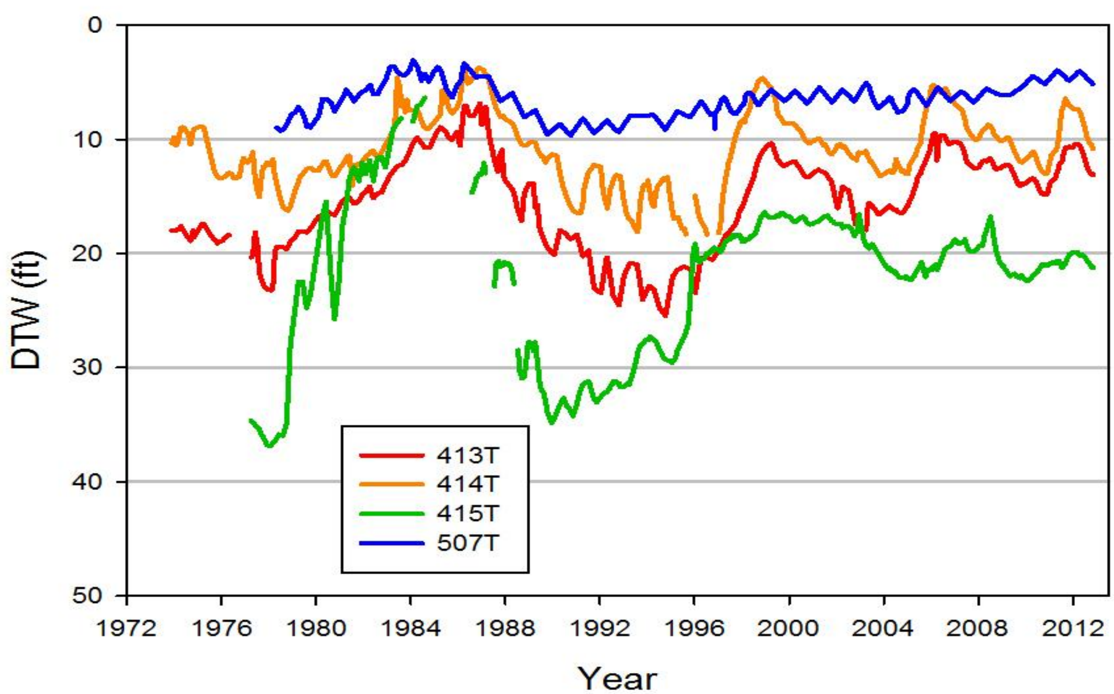


Figure 3.14. Hydrographs of selected monitoring wells in the Thibaut-Sawmill Wellfield.

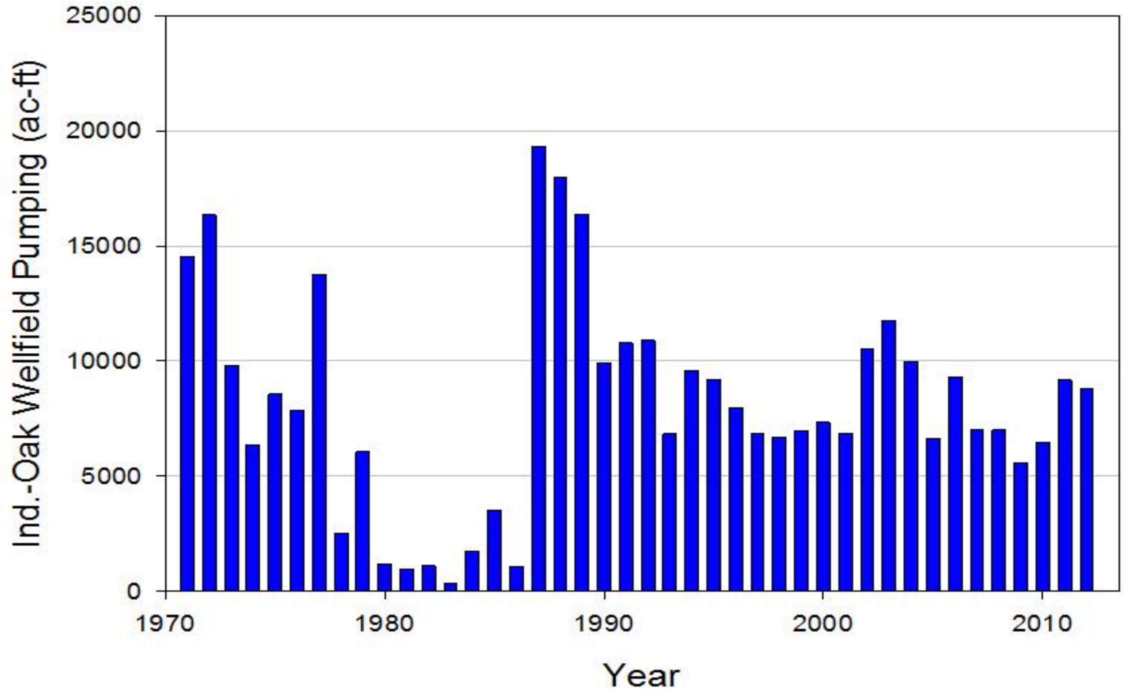
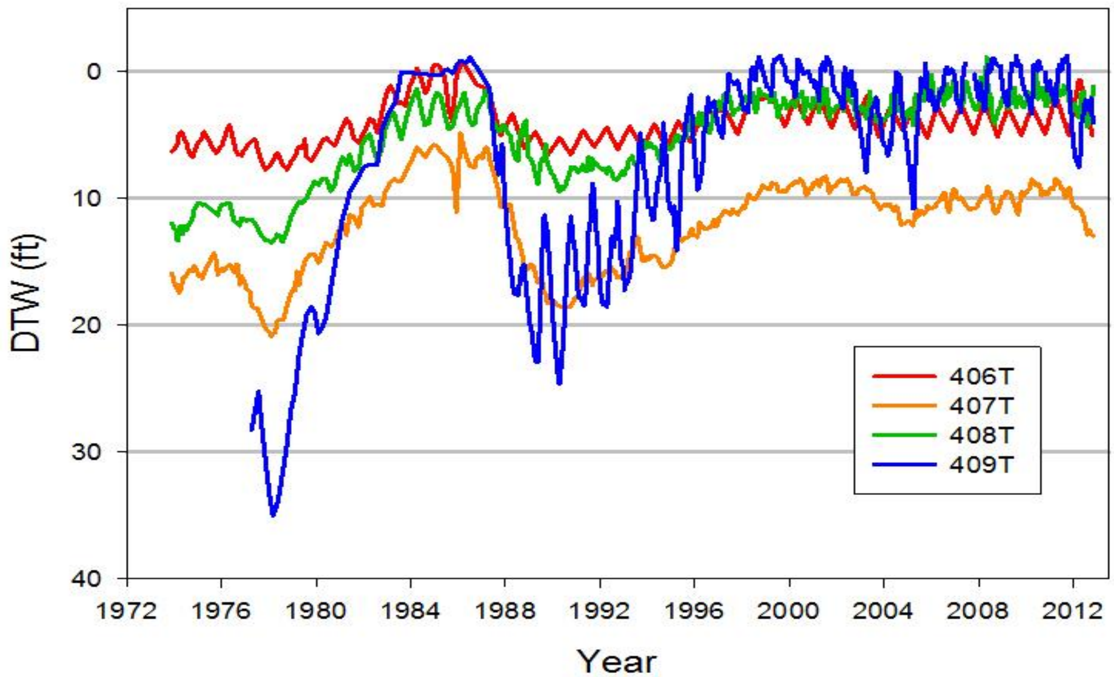


Figure 3.15. Pumping totals for the Independence-Oak Wellfield.

Following nearly ten years of stable water levels, 507T began to respond in 2009 to the establishment of wetlands in the Blackrock Waterfowl Management Area. Well 415T has declined slightly from the recent peak water level in 2008. Groundwater levels decreased in all wells in 2012-2013. All wells are now below baseline in April 2013 (Table 3.4).

Independence-Oak Wellfield

This wellfield has experienced annual pumping of approximately 6,700 ac-ft for irrigation projects surrounding Independence and for town supply (Figure 3.15). Following four years of near minimum pumping, LADWP increased pumping for the 2011-12 runoff-year to 9,175 ac-ft and 8,816 ac-ft for the 2012-13 runoff year. Water levels had been stable for several years in wells located in the center of the wellfield (407T, 408T, 409T), but they declined in response to the increased pumping of the last two years (Table 3.4). The other indicator wells located east and north of Independence have now also exhibited declining water levels (Figure 3.16 and Table 3.4). Wells 412T and 453T are not used as indicator wells, but they are included as examples of water levels in the northern portion of the wellfield. All of the indicator wells in the Independence-Oak Wellfield were below the baseline in April 2013 (Table 3.4).



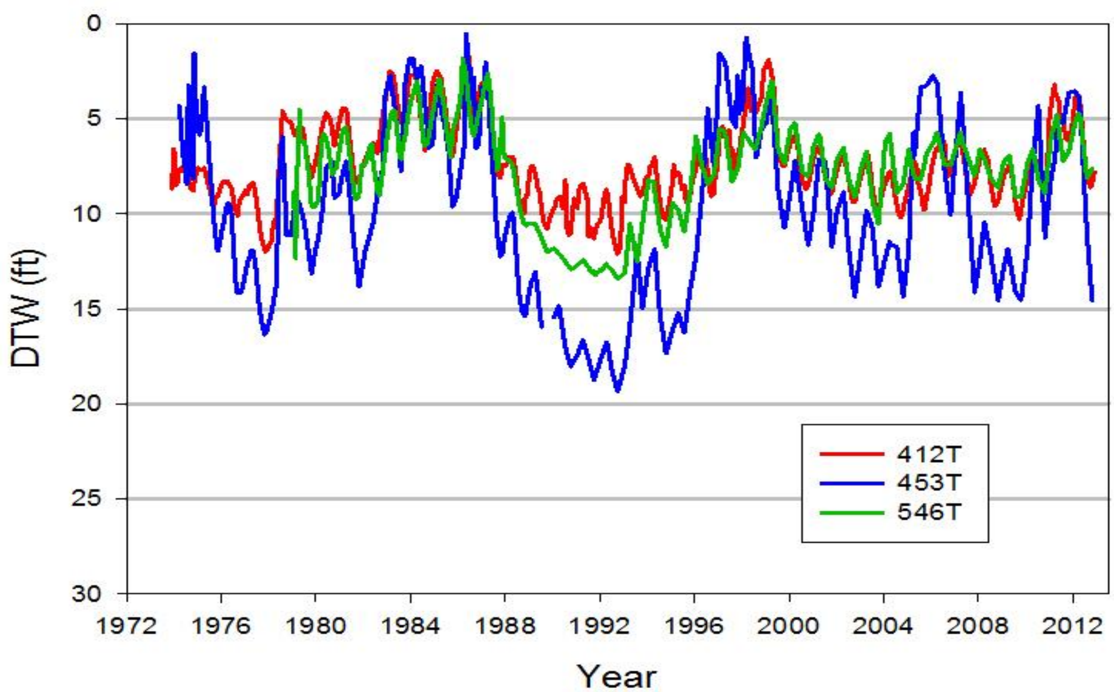


Figure 3.16. Hydrographs of selected monitoring wells in the Independence-Oak Wellfield.

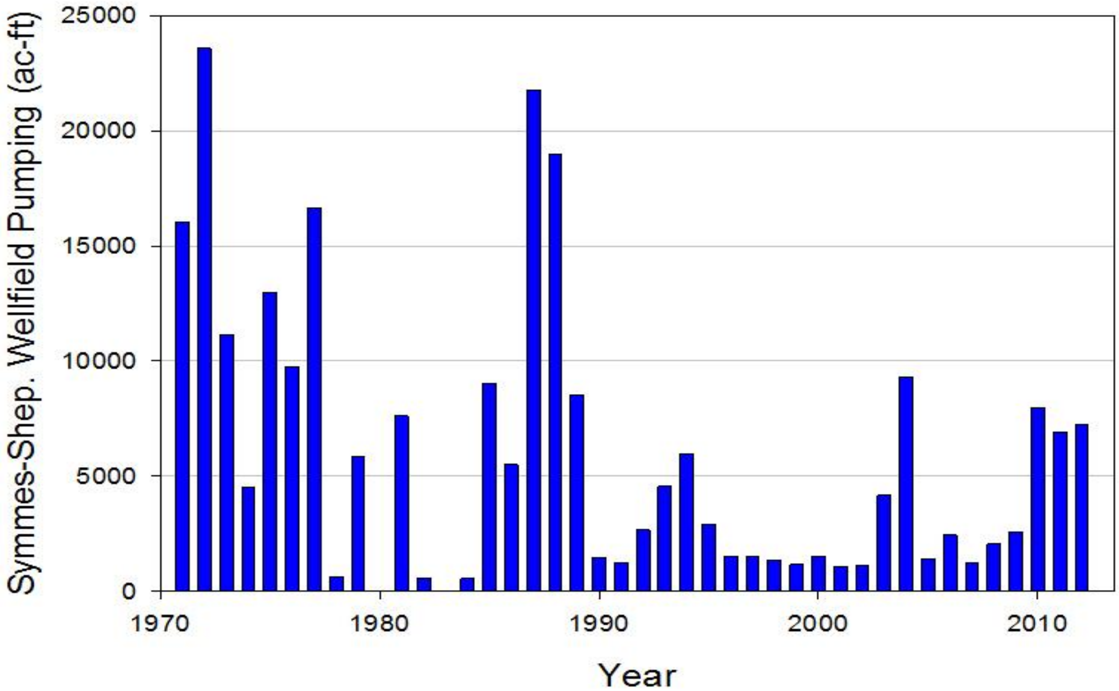
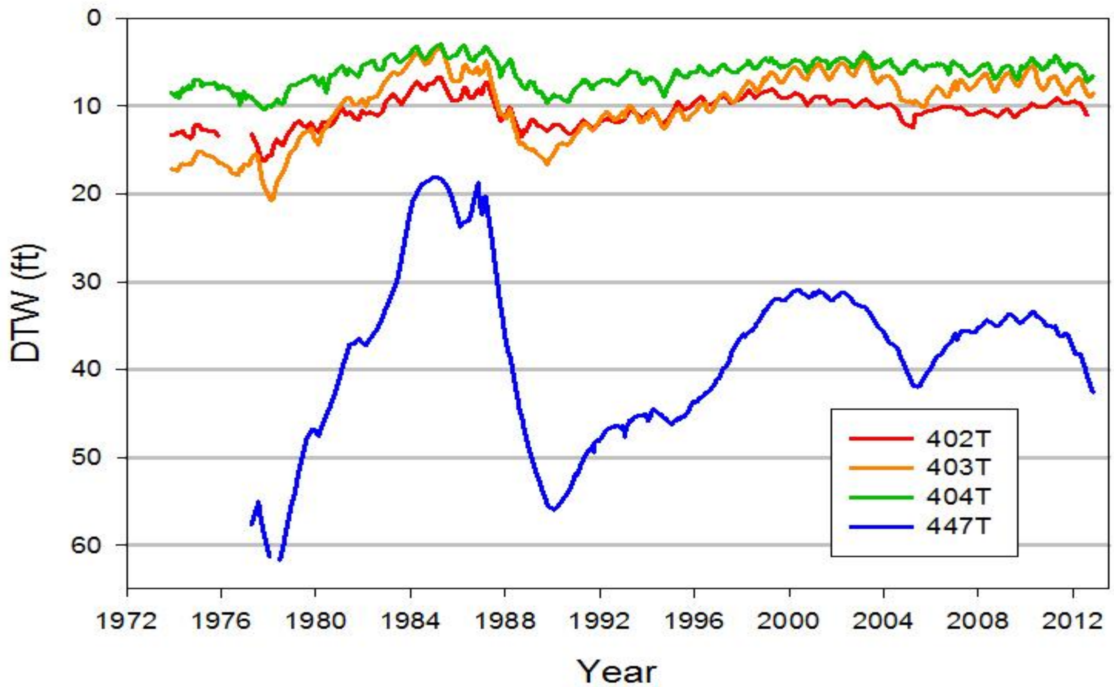


Figure 3.17. Pumping totals for the Symmes-Shepherd Wellfield

Symmes-Shepherd Wellfield

In the 1970's and 80's, pumping in the Symmes-Shepherd Wellfield varied considerably (Figure 3.17). Under the Water Agreement, pumping has been reduced to approximately 1200 ac-ft to supply one mitigation project in most years; however, pumping for aqueduct supply increased considerably in the 2010, 2011 and 2012 runoff years. Groundwater levels in 2012-2013 declined and were below baseline in all test holes (Table 3.4). The largest DTW declines occurred in 447T and the monitoring site wells located near the northern portion of the wellfield where most of pumping in 2012 occurred. The other test wells are located further from the pumping wells (403T) or are buffered somewhat by their proximity to the LAA (402T, 404T, 510T, and 511T). Water levels in these wells has been relatively stable, but declined small amounts in 2012-13.



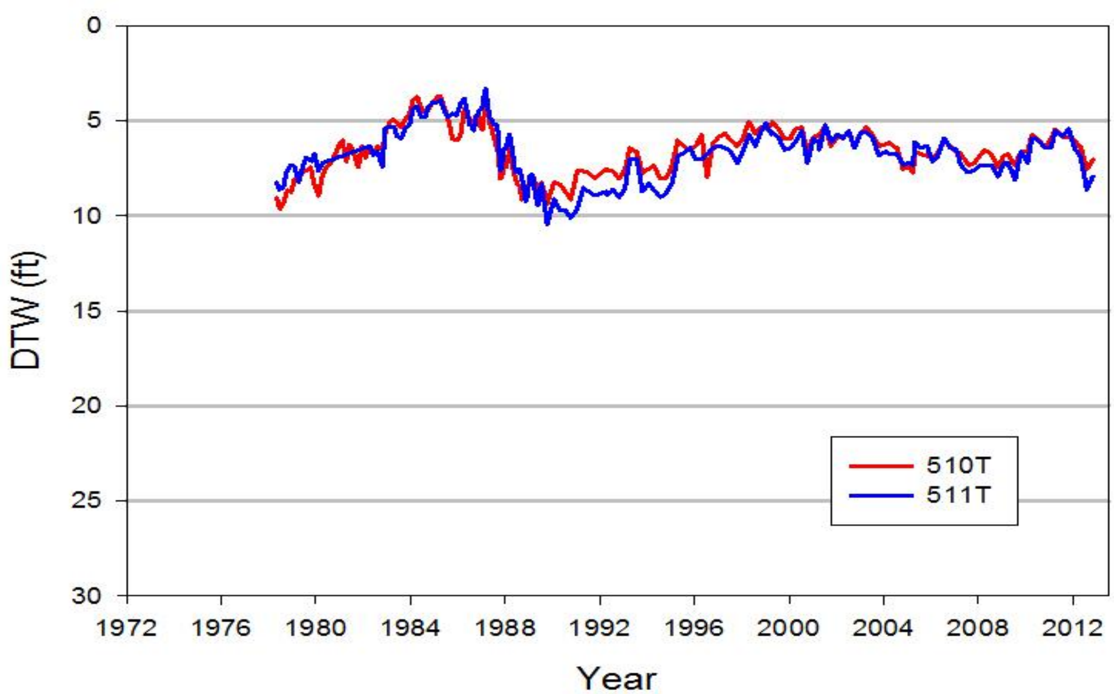


Figure 3.18. Hydrographs of indicator wells in the Symmes-Shepherd Wellfield.

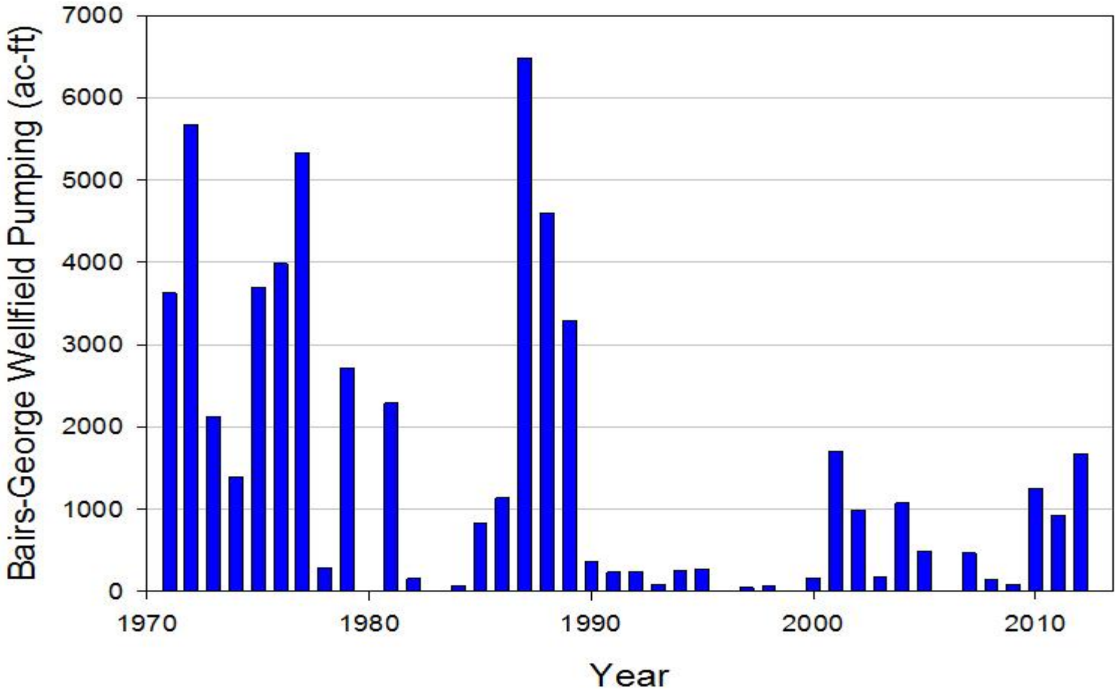


Figure 3.19. Pumping totals for the Bairs-Georges Wellfield.

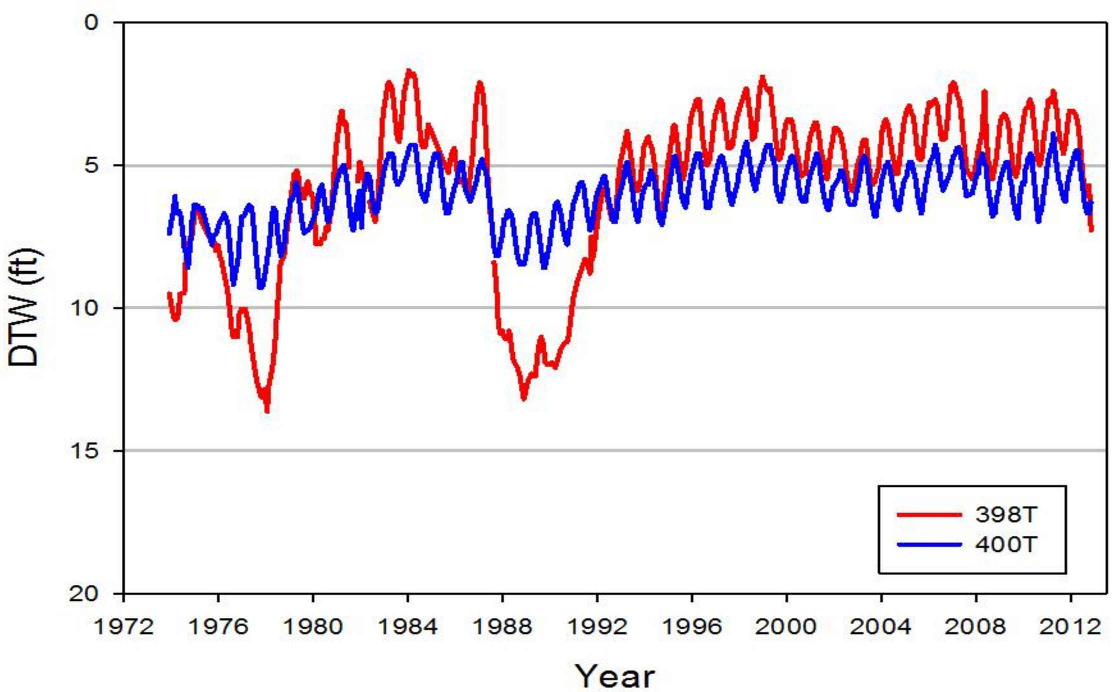


Figure 3.20. Hydrographs of indicator wells in the Bairs-Georges Wellfield.

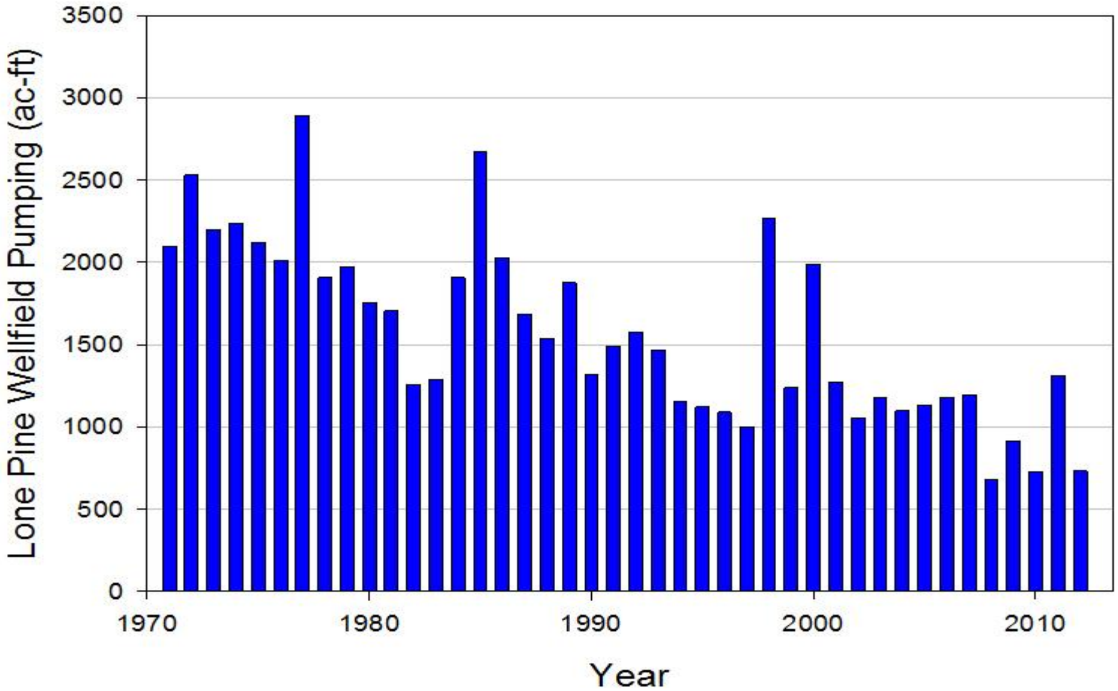


Figure 3.21. Pumping totals for the Lone Pine Wellfield.

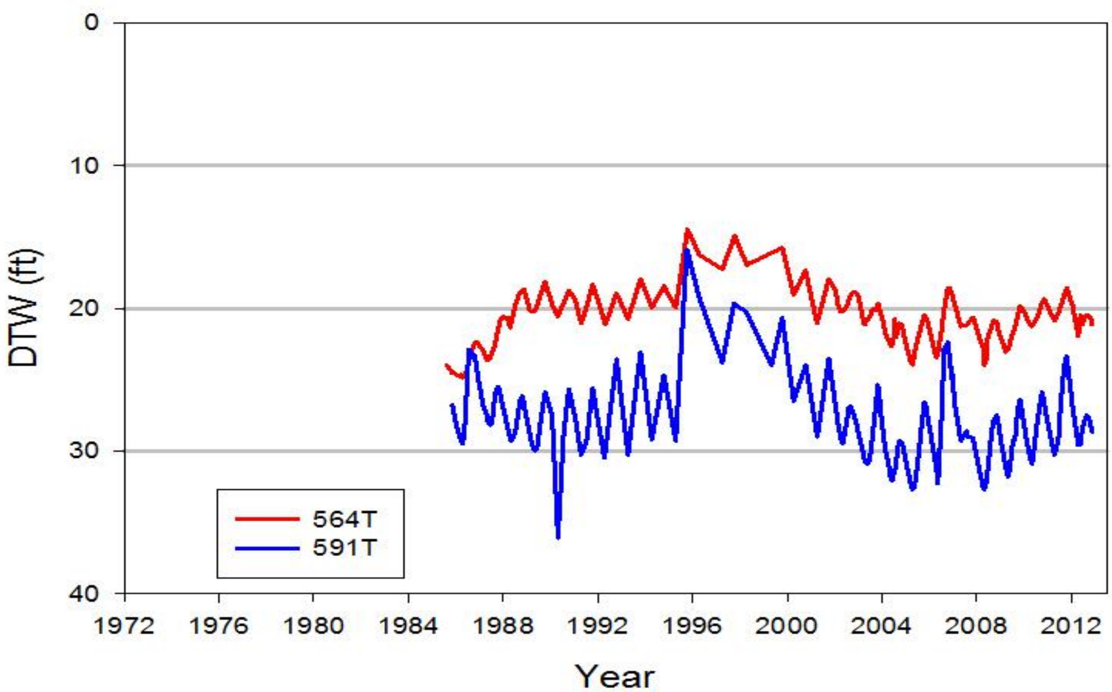


Figure 3.22.Hydrographs of selected test wells in the Lone Pine Wellfield.

Table 3.5. Selected Shallow Test Holes Adjacent to the Lower Owens River Project.

Test Well	Pre-LORP channel condition	Distance from River Channel (ft)
T467	Dry	700
T463	Dry	1070
T446	Wet	142
T448	Wet	457

Bairs-Georges Wellfield

In the 1970's and 80's, pumping and water levels in the Bairs-George wellfield varied considerably (Figure 3.19), but under the Water Agreement, pumping has been reduced substantially. There are no projects supplied by groundwater in this wellfield, but in dry years one well is exempt (W343) and can be operated to supply irrigated pastures. As in other wellfields, pumping for aqueduct supply increased considerably in 2010, 2011 and 2012 runoff years compared with the small amounts during the five preceding years. Since the mid 1990's groundwater levels in the two indicator test wells have been relatively stable (Figure 3.20). Water levels in 2012-2013 declined, and now both wells remain less than a foot below baseline in April 2013 (Table 3.5). Water levels in the indicator wells are buffered by proximity to the LAA or irrigation. Water levels at the permanent monitoring site BG2 more distant from both the pumping wells and the LAA has experienced declines since the beginning of 2012 of approximately 3 ft (see Soil Water section)

Lone Pine Wellfield

Most pumping in the Lone Pine Wellfield has been to supply the town of Lone Pine and one mitigation project (approximately 1,300 ac-ft annually). Pumping increased occasionally (e.g. 2000) to offset LAA water previously supplied to Diaz Lake. Because of the relatively constant pumping for sole source uses, we do not routinely use indicator wells to analyze the annual operations plan for this wellfield. Hydrographs for test wells T564 and T591 are presented in Figure 3.22 to represent water levels near the town of Lone Pine where the LADWP pumping wellsare located. Both wells exhibit seasonal fluctuations as well as water table response to increased recharge in wet years. In early 2010, LADWP and ICWD tested a new production well, 416W, that was installed to increase aqueduct supply. Additional testing may be performed during the 2013-14 runoff year, subject to the analysis of the results from the previous test.

Shallow Groundwater Adjacent to the Lower Owens River Project (LORP)

Base flows of 40 cubic feet per second were established in the lower Owens River in the 2007-2008 runoff-year. Five periods of higher flows to promote habitat have also been released down the Owens River channel. The effect of rewatering the LORP channel on the adjacent shallow aquifer was monitored to gain information on the surface-groundwater interaction as the project is implemented. A selected number of test wells along with the distance from the river channel are listed in Table 3.5.

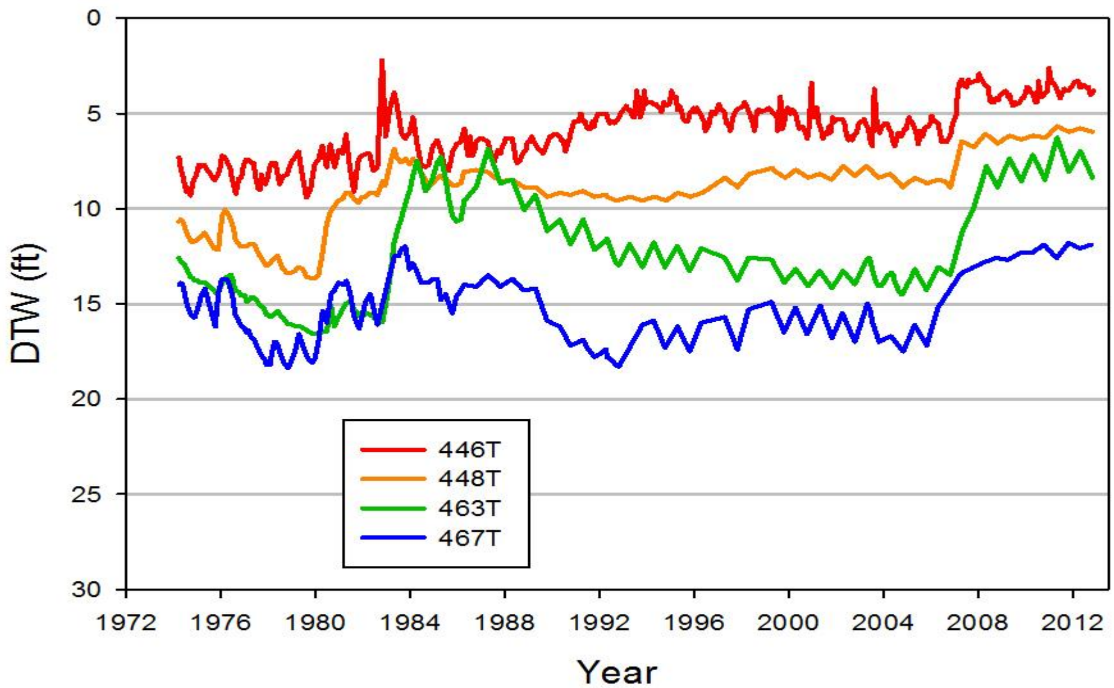


Figure 3.23. Hydrographs of selected test holes adjacent to the Lower Owens River channel.

Two test wells are adjacent to a previously dry reach of the river and two are adjacent to the reach previously wetted by diversions from LAA or from groundwater discharge (Figure 3.23). Shallow groundwater levels rose quickly in 2007 in response to the establishment of base flows in the Lower Owens River. The increase in shallow water levels due to the LORP has resulted in groundwater levels near or above the highest levels experienced since 1972. Not surprisingly, the largest increases occurred in wells adjacent to the previously dry channel. Water levels continue to rise in three of the wells suggesting the shallow aquifers adjacent to the river at greater distances from the river have not yet reached equilibrium. Test hole 446T appears to have reached equilibrium.

References

Harrington, R. F., Multiple regression modeling of water table response to groundwater pumping and runoff, Inyo County Water Department report, 1998.

Steinwand, A.L, and R.F. Harrington. 2003. Simulation of water table fluctuations at permanent monitoring sites to evaluate groundwater pumping. Report to the Inyo/Los Angeles Technical Group, February 25, 2003.

SECTION 4: SOIL WATER CONDITIONS

Introduction

The Water Agreement established procedures to determine which LADWP pumping wells can and cannot be operated based on soil water and vegetation measurements (On/Off status). As part of the monitoring effort for the Agreement, the ICWD regularly measures depth to groundwater (DTW) and soil water content at 25 sites in wellfields and eight sites in control areas. Three of the wellfield sites are not used to determine the operational status of nearby pumping wells but are monitored to maintain a continuous record. Each site is equipped with 1 to 6 soil water monitoring locations. Soil water measurements are collected using a neutron gauge calibrated for each site (Dickey, 1990; Steinwand, 1996).

The purpose for the On/Off procedures is to manage pumping to protect plant communities that require periodic access to the water table for long-term survival. Generally, the sites with On-status have wet soil and shallow water tables, and sites in Off-status have dry soil and deep water tables. Because the On/Off status is a comparison soil water and predicted transpiration, it sometimes is an unreliable indicator of whether groundwater conditions are adequate or whether water table recovery is necessary. To assist the evaluation of LADWP Annual Operations Plans, the Water Department examined the DTW and soil water data to determine whether groundwater is accessible to plants at the permanent monitoring sites at the beginning of the 2013 growing season.

How well plants can access groundwater depends on the vegetation type and soil type, as well as water table depth. In similar soils, a shallower water table is necessary to supply groundwater to grasses than shrubs because of the shallower roots of the grasses. For management purposes in the Water Agreement, shrub-dominated sites are assigned a root zone of 4 m (13.1 ft.); grass-dominated or mixed grass and shrub assemblages are assigned a root zone of 2 m (6.6 ft.). These approximate values are not the actual rooting depth at a particular monitoring site, but they are useful to compare with the soil depth that received recharge from groundwater.

The purpose for the On/Off procedures is to manage pumping to protect plant communities that require periodic access to the water table for long-term survival.

Soil water in the root zone can be supplied by infiltration from the surface (rain or irrigation) or from contact with the water table. It is usually possible to discriminate deeper soil affected by groundwater from soil near the surface affected by infiltration based on the depth and timing of the measured changes in soil water content. Plant roots can use groundwater directly, and if the water table is within the root zone it is reasonable to conclude that groundwater is available. A rising water table can progressively wet the root zone from below and provide water to plants. Plant roots can also tap groundwater that is drawn into the soil above the water table by capillarity where it is held in soil pores or adsorbed to soil particles. Plant uptake during the summer depletes soil water, and when transpiration ceases in the fall, water from the moist soil above the water table will replenish the drier soil in the root zone via capillarity or through inactive plant roots even if the water table is stable or declining. This is a slow process and usually provides much less soil water recharge than a rising water table.

Results

Monitoring results for available soil water, vegetation water requirement, water table depth, and the On/Off status for all sites are presented in the figures contained in Appendix A. (The graphs in Appendix A are periodically updated and available on the ICWD website.) At the beginning of the 2012-13 runoff year, eight sites were in On status. Site BP3 went into Off status in July, and site TS3 went into Off status in October. The other six sites remained in On-status throughout the runoff year. No sites went into On status during the winter 2012-13. The six sites in On status as of May, 2013 were: L2, BP4, TA5, TS2, SS1, and BG2.

Hydrographs for the permanent monitoring sites are presented in Appendix A, and the minimum (shallowest) DTW measured during the fall and winter preceding the 2012 and 2013 growing seasons are presented in Table 4.1. The minimum DTW is a useful measurement because it is associated with the amount of groundwater recharge in the root zone before the beginning of the growing season. At most sites, the minimum DTW occurs in the spring. At sites BP1, 2, and 3 in Big Pine, the water table rises during the summer and reaches a minimum in the fall coinciding with the timing of diversions into the Big Pine canal for irrigation. For these three sites, the amount and depth of soil water recharge during the winter are related to the minimum water table depth in the fall.

The water table was deeper at all wellfield and all control sites in 2013 compared with 2012. The preceding winter's runoff (2011-12) was much below normal and pumping was approximately the same as 2011-12, so a general decline was expected (see the Groundwater section of this report.) Notable declines greater than 0.6 m (approximately 2 ft.) occurred at wellfield sites L1, BP1, BP3, TS6, IO1, IO2, SS1, SS2, and BG2. The cause of the relatively large decline at BC3 is unknown. Since 1989 when monitoring began, the water table had risen each winter, but that did not occur in 2011-12 or 2012-13. Additional investigation will be conducted to determine if LADWP pumping or surface water operations could have caused the change in water table fluctuations.

At most sites it was possible to discriminate groundwater recharge from surface infiltration because of the dry winter in 2012-13 (Tables 4.2 and 4.3). Infiltration was limited to depths within 0.5 m of the surface at most sites, and much of the observed infiltration evaporated during the winter. The monitoring sites were grouped into simple categories to summarize the connection between soil water in the root zone and the water table. Brief descriptions of the three categories and the results are given below:

1. Connected: Water table fluctuations resulted in soil water recharge in the top half of the root zone at most monitoring locations within a site. Three wellfield and five control sites were placed in this category.

2. Partially connected: Water table fluctuations resulted in soil water recharge in the bottom half of the root zone at most monitoring locations within a site. Six wellfield and one control site occur in this category. The control sites and TA1, TA2, TS3, TS6, and SS3 have ample soil water stored in the soil profile.

Table 4.1. Minimum DTW during the fall and winter preceding the growing seasons in 2012 and 2013. For some sites with a steadily declining water table, measurements near April 1 were compared for both years. Hydrographs for the sites are provided in Appendix A. Depths are below ground surface.

Site	2012 DTW	2013 DTW	DTW Change 2012-13†
	(m)	(m)	(m)
L1	7.09	7.79	-0.70
L2	7.05	7.22	-0.17
L3	4.80	5.12	-0.32
BC1	3.00	3.18	-0.18
BC2	4.35	4.48	-0.13
BC3	2.21	2.64	-0.43
BP1	3.48	4.39	-0.91
BP2	5.31	5.75	-0.44
BP3	4.14	5.08	-0.94
BP4	5.15	5.56	-0.41
TA1 & 2	1.75	2.15	-0.40
TA3	5.23	5.74	-0.51
TA4	2.58	2.99	-0.41
TA5	4.60	4.86	-0.26
TA6	3.64	4.19	-0.55
TAC	1.06	1.56	-0.50
TS1	5.15	5.48	-0.33
TS2	3.66	3.85	-0.19
TS3	1.33	2.09	-0.76
TS4	2.15	2.38	-0.23
TS6	2.86	3.91	-1.05
TSC	1.12	1.71	-0.59
IO1	2.39	3.57	-1.18
IO2	8.61	10.04	-2.43
IC1	0.83	0.98	-0.15
IC2	2.31	2.45	-0.18
SS1	5.08	6.62	-1.54
SS2	7.72	NA††	>1.11
SS3	4.04	4.11	-0.07
SS4	6.00	6.25	-0.25
BG2	4.58	5.45	-0.87
BGC	2.24	2.71	-0.47

†: positive values denote a rise in the water table.

††: Monitoring well is dry at approximately 8.4m.

Table 4.2. Soil depth below ground surface replenished by groundwater in 2012-2013 at control sites. Values are provided for each monitoring location within a site. DTW was measured in the associated test well, and the values do not account for elevation differences between the well and monitoring site.

Site	Dominant plant species	Root Zone	Minimum DTW	Groundwater recharge depth
		(m)	(m)	(m)
BC1	rabbitbrush, saltbush, greasewood, alk. sacaton	4	3.18	2.5, 1.5, 2.5
BC2	rabbitbrush, saltgrass	2	4.49	<1.0 at all four locations†
BC3	rabbitbrush, saltgrass, saltbush	2	2.64	<1.3, <1.3, <1.3
TAC	saltbush, rye grass, saltgrass, alk. sacaton	2	1.56	0.3, 0.5, 0.5, 0.3
TSC	alk. sacaton, rabbitbrush, greasewood.	2	1.71	0.9, 0.5, 0.7
IC1	saltbush, saltgrass, rabbitbrush	2	0.98	0.9, 0.9, 0.3
IC2	rabbitbrush, alk. sacaton	2	2.45	>2.3, 2.1, >2.7
BGC	saltbush, saltgrass	4	2.71	0.9, 1.1, 1.7

†: Less than symbols (<) denote locations where both infiltration and groundwater recharge contribute to increasing soil water content above the depth indicated

3. Disconnected: No recharge from groundwater occurred in the root zone. Sixteen wellfield sites and two control sites occur in this category. The control sites and L2, BP4, TA4, TA5, SS1, and BG2 had retained soil water available to plants, but the water table at the beginning of the 2013 growing season is too deep to recharge the root zone. Soil at the other sites is dry.

No site was placed in a wetter category in 2013 compared with 2012 reflecting the general water table decline. The control sites had similar or slightly drier soil conditions in both years. In 2012, all control sites were in connected or partially connected categories. During 2012-13 two sites, BC3 and IC2, did not receive groundwater recharge into the root zone (Figure 4.1). The soils above the water table at all control sites still had ample retained water. At the beginning of the 2013 growing season, the water table was capable of supplying water to the root zone at nine wellfield monitoring sites (Figure 4.1), five fewer sites than in 2012. Sixteen sites were classified as disconnected including the five sites added this year: BP1, BP2, BP3, TA4, and BG2. Six sites in the disconnected category still retain soil water following water table decline (L2, BP4, TA4, SS1, and BG2) or because the plant cover is low and the soil is always moist (TA5). The remaining ten sites have dry soil throughout the root zone. As in previous years, interpretations for TA5 were atypical. Soil at this site was moist at lower depths but relatively unchanging. Plant uptake during the summer was not evident below two meters, and soil water recovery when plant uptake ceased in the fall or related to water table fluctuations was not evident. The DTW at TA5 is much below the 2m root zone, and the site was classified as disconnected as it was in 2012.

Monitoring locations at five sites, L1, TA3, SS4, IO1, and TS4 exhibited increasing soil water content at certain depths well above the water table while lower depths showed no change in water content. The change in water content at those sites was small (<0.06 $m^{3/}m^3$), sometimes barely detectable. Simple capillary rise to recharge shallower depths while not affecting unsaturated soil just above the water table is unusual. Water can be transported from wetter, deeper soil layers through plant roots to recharge dry soil at shallower depths (Horton and Hart, 1998; Jackson et al., 2000) but without additional information, assigning that cause is speculative. Regardless of the exact mechanism causing the increase in soil water, the monitoring and On/Off management was able to measure and account for that source of water.

References

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Horton, J.L. and S.C. Hart. 1998. Hydraulic lift: a potentially important ecosystem process. Tree 13:232-235.

Jackson, R.B., J.S. Sperry, and T.E. Dawson. 2000. Root water uptake and transport: using physiological processes in global predictions. Trends Plant Sci. 5:482-488.

Steinwand, A.L, 1996. Protocol for Owens Valley neutron probe soil water monitoring program. Report to the Inyo/Los Angeles Technical Group, August 6, 1996.

Table 4.3. Soil depth below ground surface replenished by groundwater in 2012-2013 at wellfield sites. Values are provided for each monitoring location within a site unless the identification of a specific depth was uncertain. DTW was measured in the associated test well, and the values do not account for elevation differences between the well and monitoring site.

Site	Dominant plant species	Root Zone	Minimum DTW	Groundwater recharge depth
		(m)	(m)	(m)
L1	greasewood	4	7.79	>3.9, 2.5†, 3.1†
L2	alk. sacaton, greasewood, saltbush	2	7.22	>3.9, 3.7, >3.9, >3.9, 3.9
L3	alk. sacaton, saltgrass	2	5.12	0.9, 3.3, 0.9, 0.5, 0.9, 1.3
BP1	saltbush, greasewood	3	4.39	3.5, 3.3, 1.1, 1.7, 3.9
BP2	saltbush, rabbitbrush	4	5.75	4.5, >3.9, >3.9
BP3	greasewood, rabbitbrush	4	5.08	>3.9 at all three locations
BP4	saltbush, greasewood	4	5.56	1.9, >3.9, >3.9
TA1	alk. sacaton, saltbush	2	2.15	1.3
TA2	alk. sacaton, saltbush, greasewood, rabbitbrush	2	2.15	1.1
TA3	saltbush, alk. sacaton, sagebrush	2	5.74	>3.9, >3.9, 2.5†
TA4	rabbitbrush, alk. sacaton	2	2.99	>3.9, >2.1, >2.1
TA5	greasewood, alk. sacaton	2	4.86	
TA6	saltbush, rabbitbrush	2	4.19	2.9, 3.1, 3.1
TS1	weeds, alk. sacaton	2	5.48	>3.9, 3.1, >3.9, >3.9, >3.9
TS2	sagebrush, saltbush, alk. sacaton	2	3.85	3.5, 3.5, 2.5
TS3	saltgrass, alk. sacaton	2	2.09	0.9, 0.3, 0.7, 1.7, 1.7, 2.3
TS4	greasewood, alk. sacaton, saltbush, saltgrass	2	2.38	0.3†, 0.3†, 1.1, 0.5
TS6	alk. sacaton, saltbush, saltgrass	2	3.91	1.5
IO1	rabbitbrush, alk. sacaton, saltbush	2	3.57	1.1†, 0.3†, 0.7†
IO2	saltbush	4	10.04	>5.5, >3.9, >3.9
SS1	saltbush, greasewood	4	6.62	>5.5, >3.9, >3.9
SS2	saltbush	4	NA††	>5.5, >3.9, >3.9
SS3	saltbush	4	4.11	2.3†, >3.9, 1.9
SS4	saltbush	4	6.25	3.9, >3.9, 2.5†
BG2	inkweed, saltbush	4	5.45	>3.9, >3.9, >3.9

†: Soil water content at these depths increases slightly during winter but deeper soil remains approximately constant suggesting that the recharge mechanism is not simple capillary rise above the water table. The change in water content is usually small (< 0.06 m^3/m^3).

††: The water table is deeper than the bottom of the monitoring well at 8.4m.

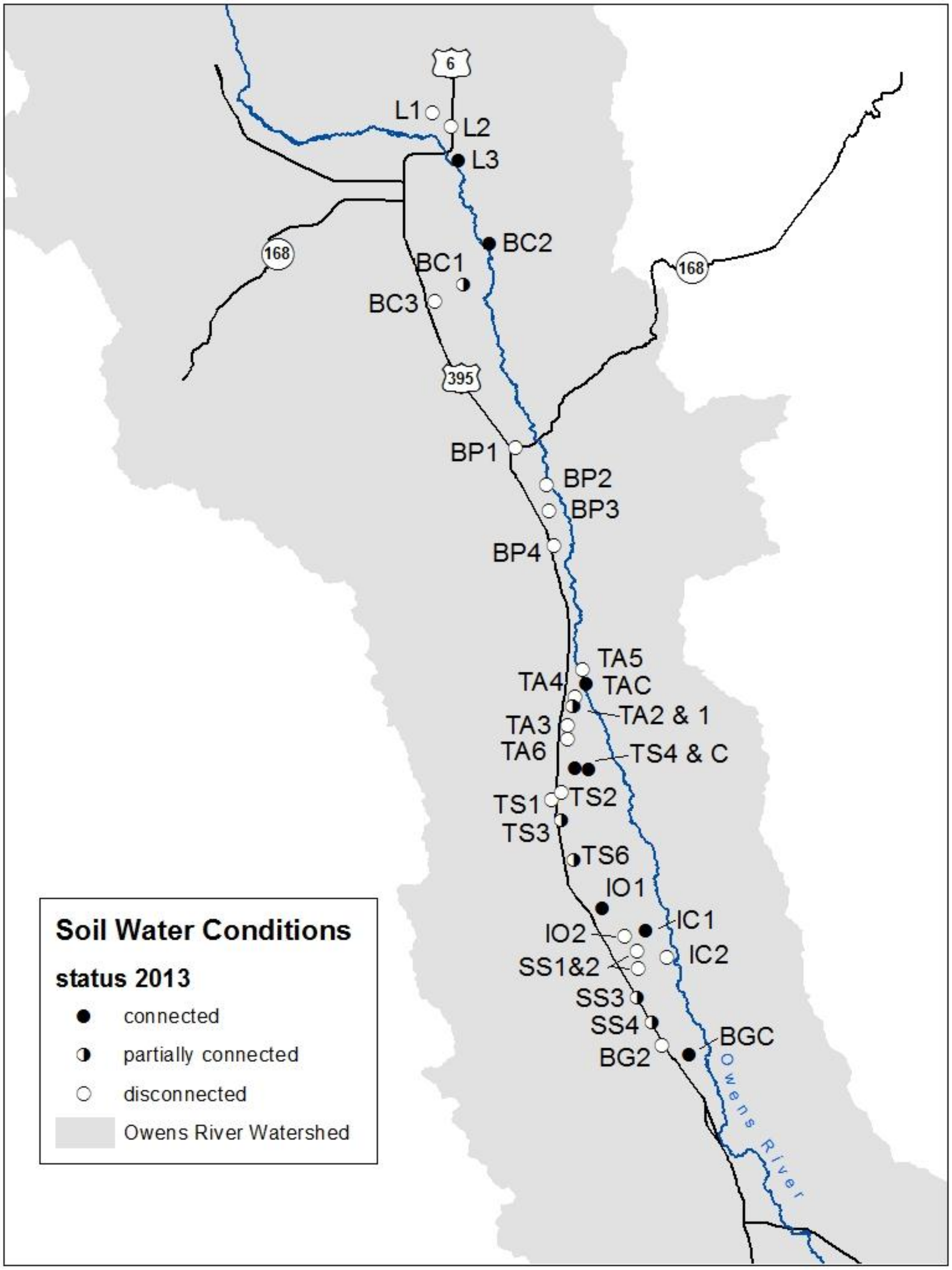


Figure 4.1. Owens Valley permanent monitoring sites and groundwater recharge classes.

Appendix A

July 1 and October 1 On/Off calculation tables for the permanent monitoring sites and graphs containing the soil-plant water balance and groundwater data and. No sites entered On status between October, 2012 and April 2013.

Table A1. June 2012 monitoring site status and July 1, 2012 soil/vegetation water balance calculations according to Green Book, Section III.

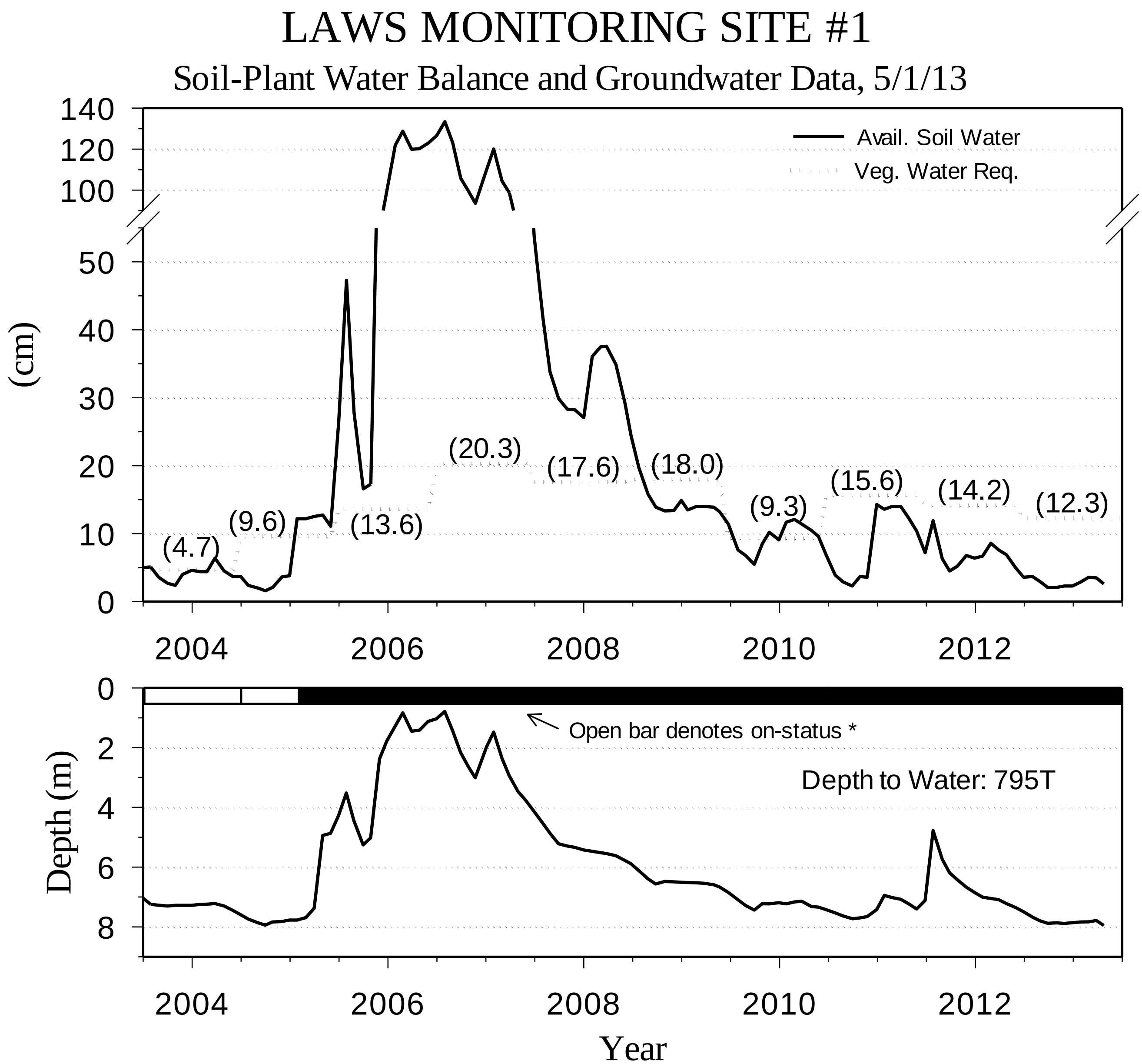
Site	June, 2012 Status	July, 2012 Veg. Water Req./ Soil AWC for turn-on	July 2012 soil AWC	July 2012 Status	Soil AWC required. for well turn-on
		(cm)	(cm)		(cm)
L1	OFF	7.0/15.6	3.6	OFF	15.6, OFF 7-10
L2	ON	5.1/NA	21.5	ON	NA
L3	OFF	6.6/25.2	9.6	OFF	25.2, OFF 10-11
BP1	OFF	8.4/22.9	9.1	OFF	22.9†, OFF 10-97
BP2	OFF	7.5/28.4	2.8	OFF	28.4, OFF 7-98
BP3	ON	6.0/NA	5.9	OFF	10.6. OFF 7-12
BP4	ON	7.9/NA	54.6	ON	NA
TA3	OFF	13.3/26.0	9.7	OFF	26.0, OFF 10-11
TA4	OFF	9.3/23.3	15.9	OFF	23.3, OFF 10-11
TA5	ON	3.4/NA	22.5	ON	NA
TA6	OFF	13.7/17.6	11.3	OFF	17.6, OFF 10-11
TS1	OFF	4.4/20.4	1.9	OFF	20.4†, OFF 10-96
TS2	ON	4.0/NA	9.8	ON	NA
TS3	ON	17.9/NA	34.3	ON	NA
TS4	OFF	28.5/55.9	40.2	OFF	55.9, OFF 10-11
IO1	OFF	47.7/42.2	33.2	OFF	42.2, OFF 10-98
IO2	OFF	5.8/18.9	5.3	OFF	18.9, OFF 7-11
SS1	ON	14.6/NA	28.3	ON	NA
SS2	OFF	6.4/25.6	3.6	OFF	25.6, OFF 7-11
SS3	OFF	13.1/33.8	23.4	OFF	33.8, OFF 10-11
SS4	OFF	4.1/15.9	6.5	OFF	15.9, OFF 7-05
BG2	ON	6.6/NA	29.0	ON	NA

†: These values of soil water required for well turn-on were derived using calculations based on % cover that were routinely performed in the past. The values have not been updated to conform to the Green Book equations in section III.D.2, p. 57-59.

Table A2. July 2012 monitoring site status and October 1, 2012 soil/vegetation water balance calculations according to Green Book, Section III.

Site	July 1, 2012 Status	October, 2012 Veg. Water Req./Soil AWC for turn-on	October 2012 soil AWC	+50% annual ppt.	October 1 2012 Status	Soil AWC req. for well turn-on
		(cm)	(cm)	(cm)		(cm)
L1	OFF	12.3/15.6	2.1	NA	OFF	15.6, OFF 7-10
L2	ON	9.1/NA	17.5	17.5 + 7.9 = 25.4	ON	NA
L3	OFF	12.0/25.2	7.4	NA	OFF	25.2, OFF 10-11
BP1	OFF	15.3/22.9	5.4	NA	OFF	22.9†, OFF 10-97
BP2	OFF	13.9/28.4	2.4	NA	OFF	28.4, OFF 7-98
BP3	OFF	10.6/10.6	5.0	NA	OFF	10.6. OFF 7-12
BP4	ON	14.1/NA	49.6	49.6 + 8.2 = 57.8	ON	NA
TA3	OFF	25.0/26.0	7.3	NA	OFF	26.0, OFF 10-11
TA4	OFF	17.3/23.3	14.5	NA	OFF	23.3, OFF 10-11
TA5	ON	6.2/NA	20.7	20.7 + 8.2 = 28.9	ON	NA
TA6	OFF	25.5/17.6	9.1	NA	OFF	17.6, OFF 10-11
TS1	OFF	8.3/20.4	1.5	NA	OFF	20.4†, OFF 10-96
TS2	ON	7.4/NA	8.0	8.0 + 7.3 =15.3	ON	NA
TS3	ON	32.9/NA	23.9	23.9 + 7.3 = 31.2	OFF	32.9, OFF 10-12
TS4	OFF	51.7/55.9	29.9	NA	OFF	55.9, OFF 10-11
IO1	OFF	88.8/42.2	26.3	NA	OFF	42.2, OFF 10-98
IO2	OFF	10.7/18.9	3.7	NA	OFF	18.9, OFF 7-11
SS1	ON	26.6/NA	24.3	24.3 + 6.5 = 30.8	ON	NA
SS2	OFF	11.9/25.6	3.3	NA	OFF	25.6, OFF 7-11
SS3	OFF	24.4/33.8	22.9	NA	OFF	33.8, OFF 10-11
SS4	OFF	7.7/15.9	6.1	NA	OFF	15.9, OFF 7-05
BG2	ON	12.1/NA	27.5	27.5 + 6.6 = 34.1	ON	NA

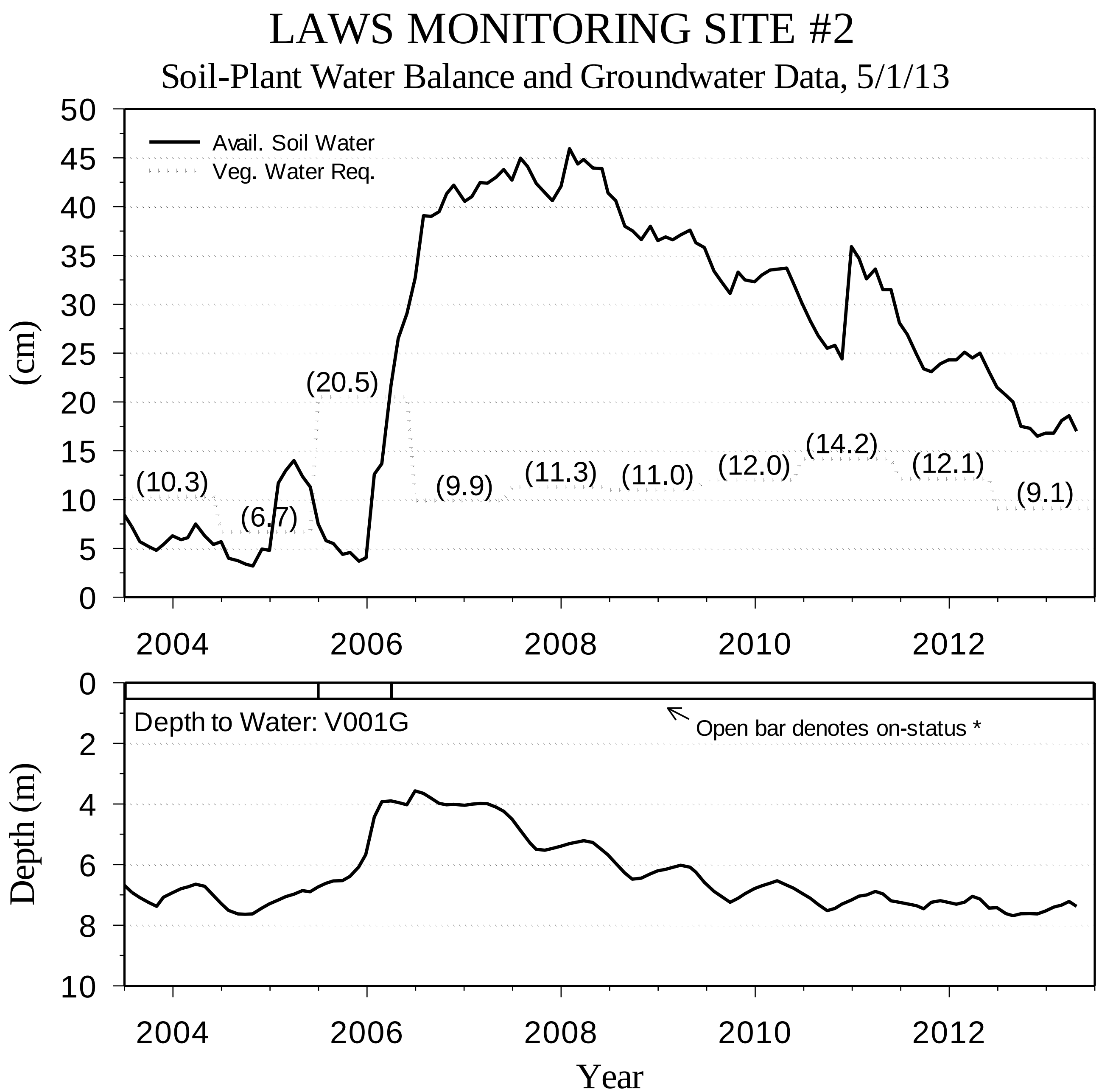
†: These values of soil water required for well turn-on were derived using calculations based on percent cover that were routinely performed in the past. The values have not been updated to conform with the Greenbook equations in section III.D.2, p. 57 -59.



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells- 247, 248, 249, 398

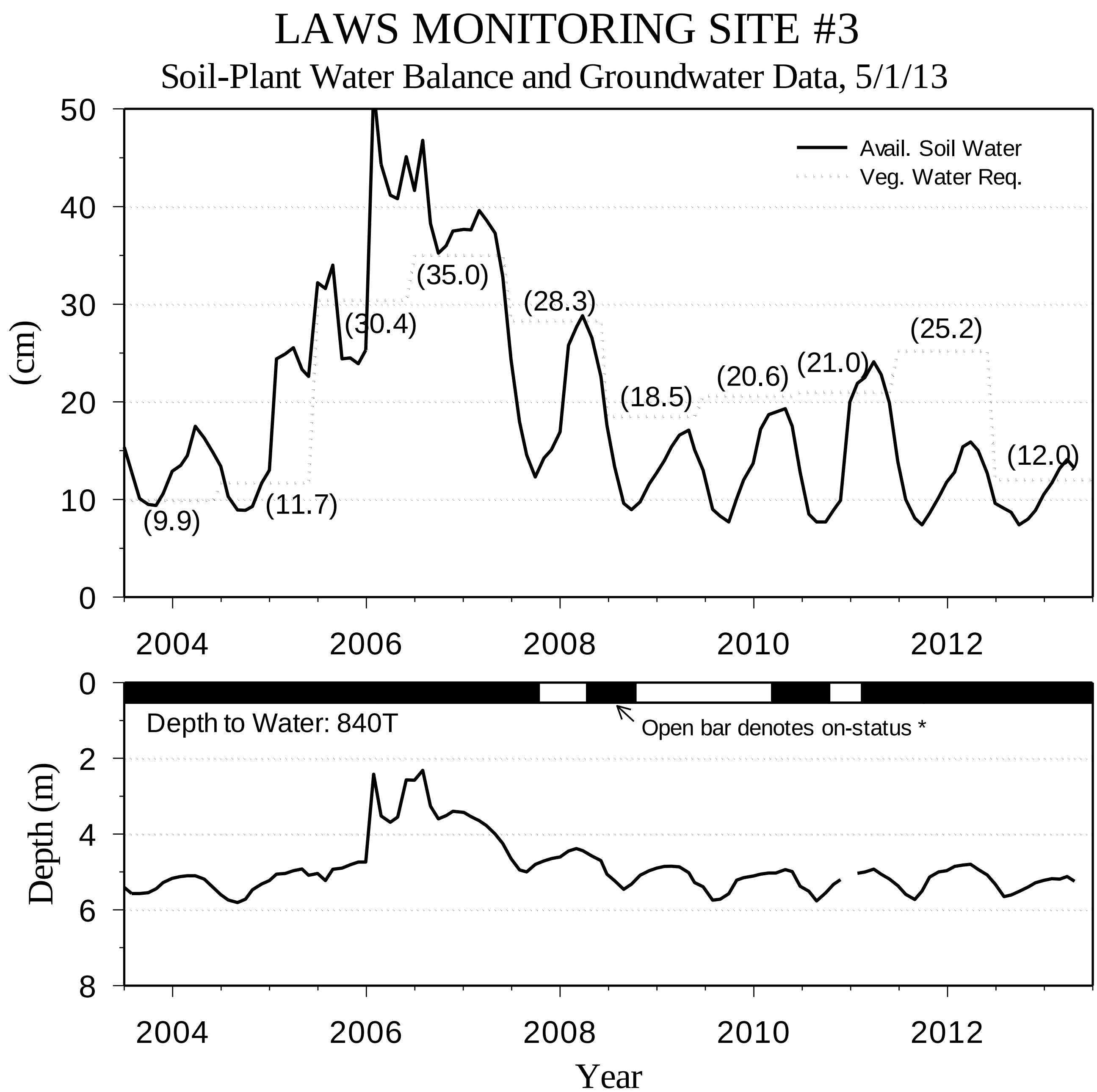
Soil water required for turn on (15.6 cm)



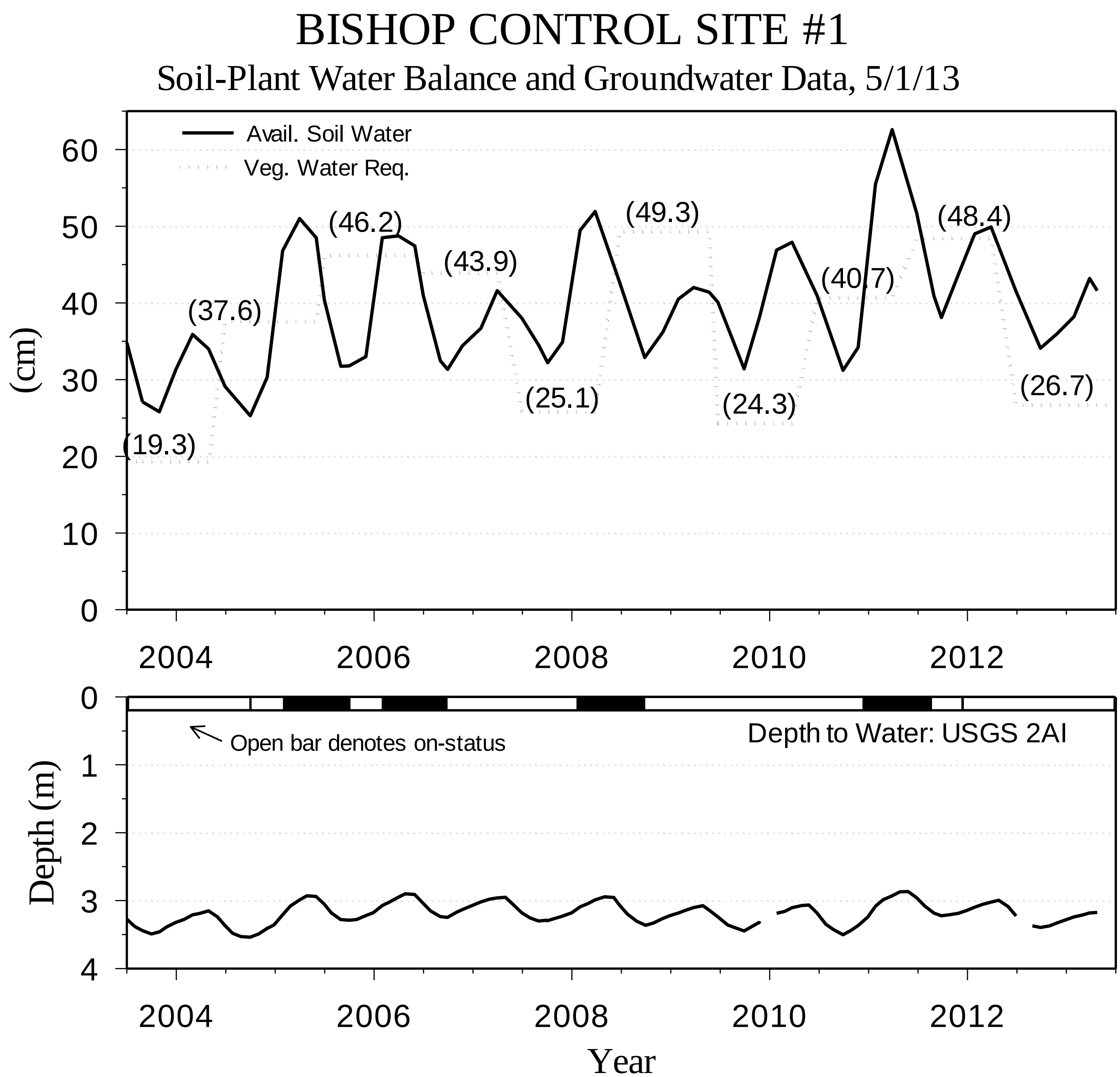
* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 236, 239, 243, 244

Soil water required for turn on (--)

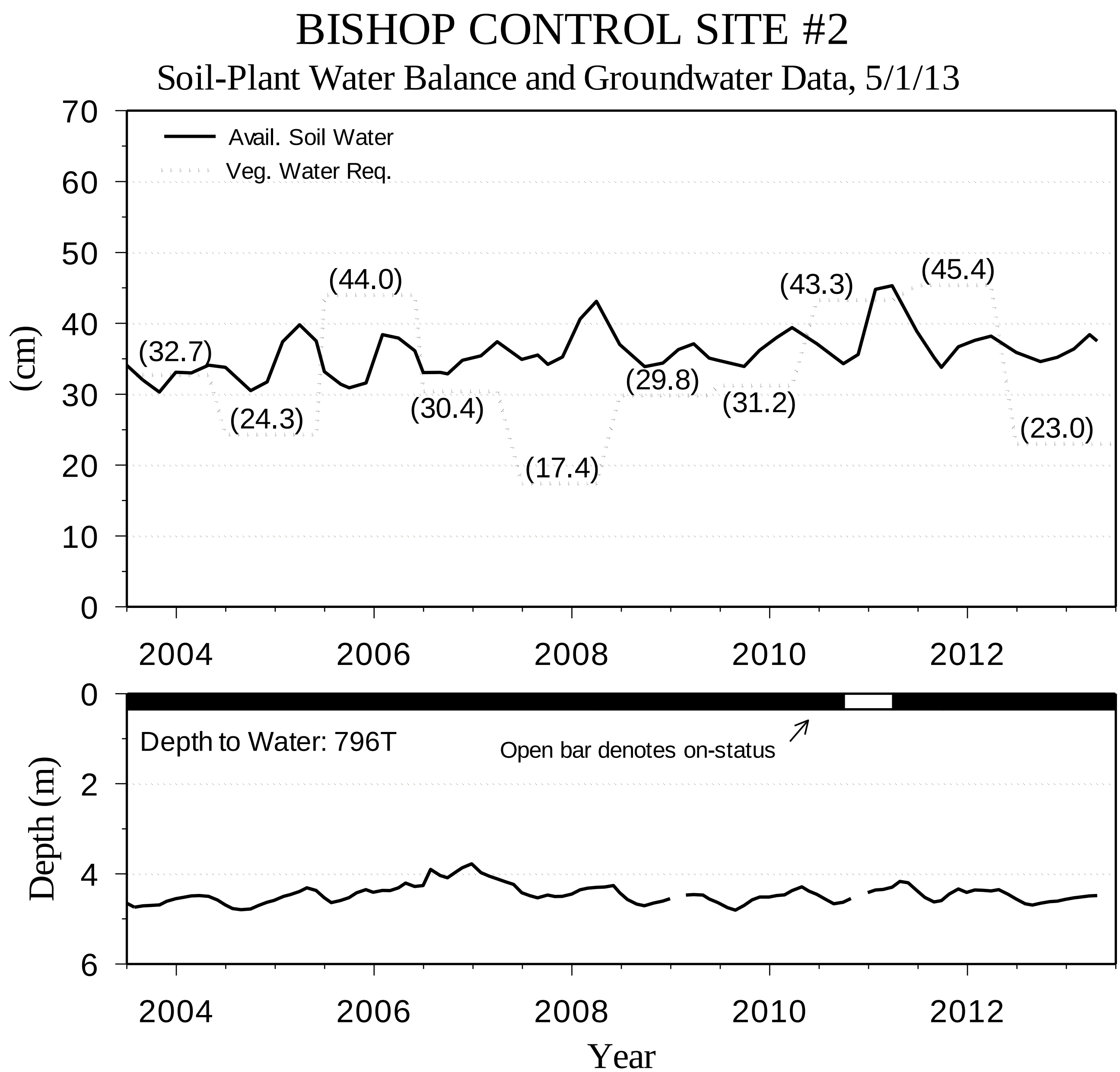


* Wells not necessarily operated when in on-status. On\off according to
Green Book Section III values for Veg. Water Req.
Linked pumping wells - 240, 241, 399, 376, 377
Soil water required for turn on (25.2 cm)



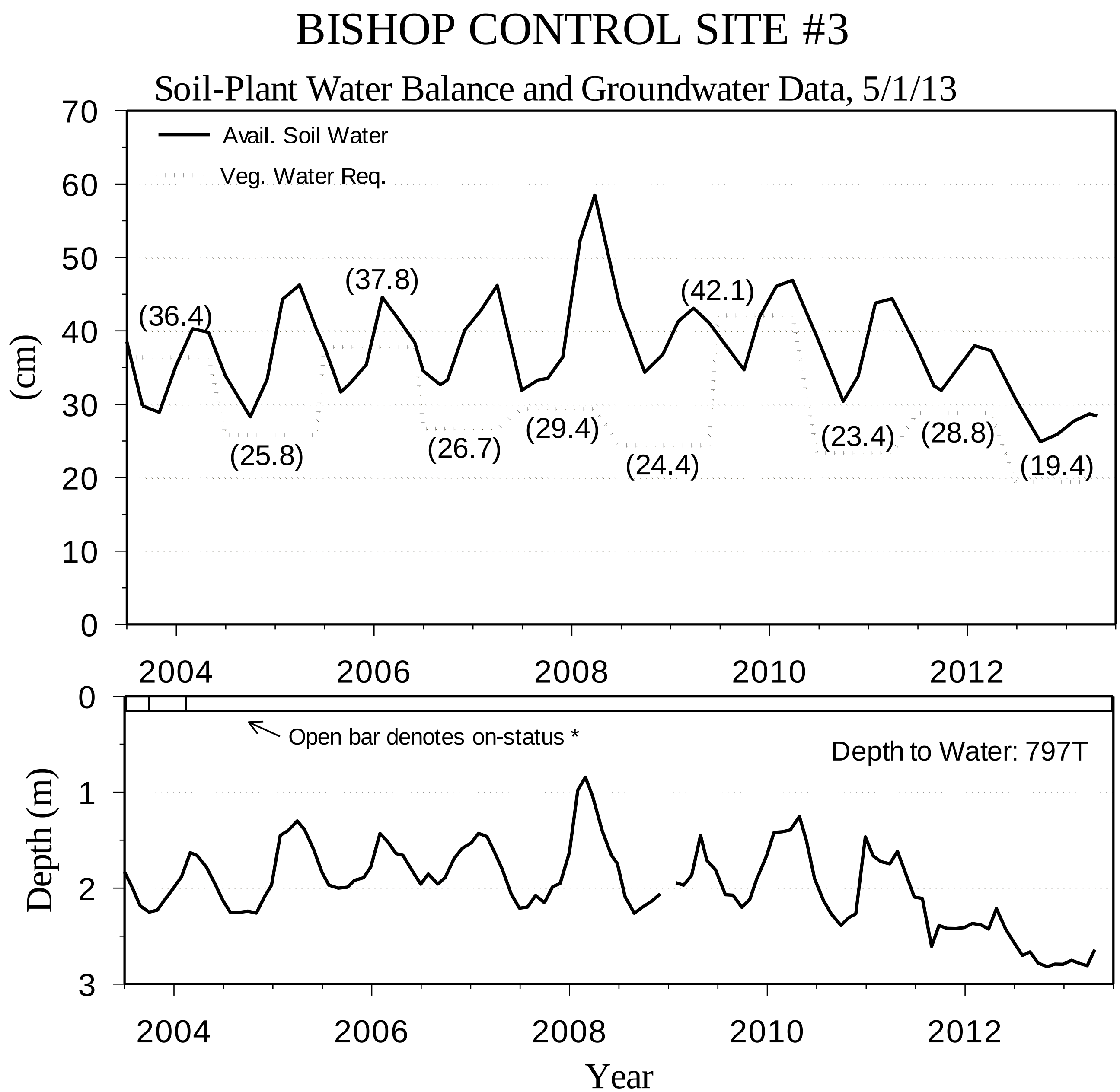
*On/off according to the Green Book Section III values for Veg. Water Req.

Soil water required for turn on (--)



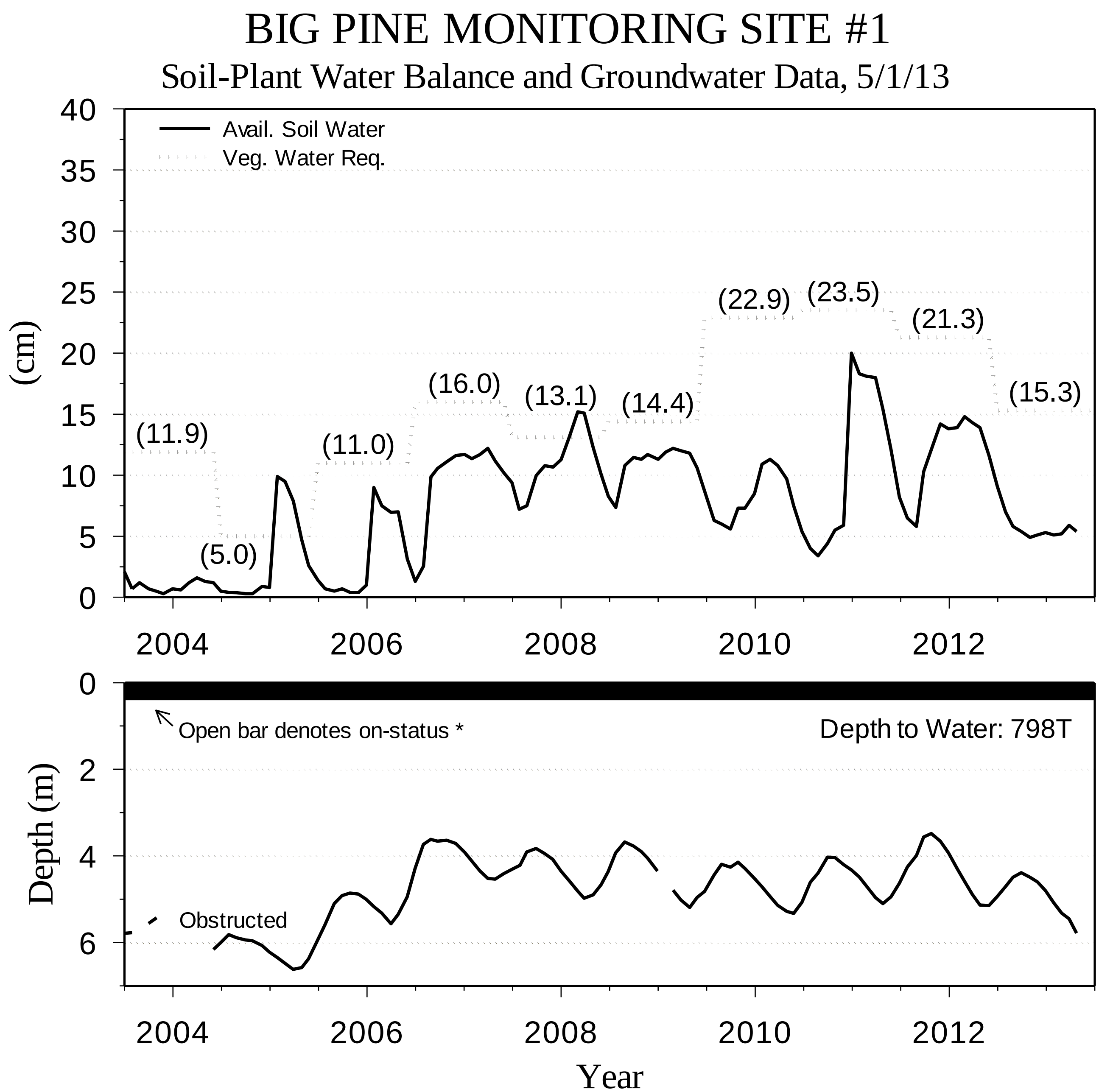
*On/off according to the Green Book Section III values for Veg. Water Req.

Soil water required for turn on (--)



*On/off according to the Green Book Section III values for Veg. Water Req.

Soil water required for turn on (--)



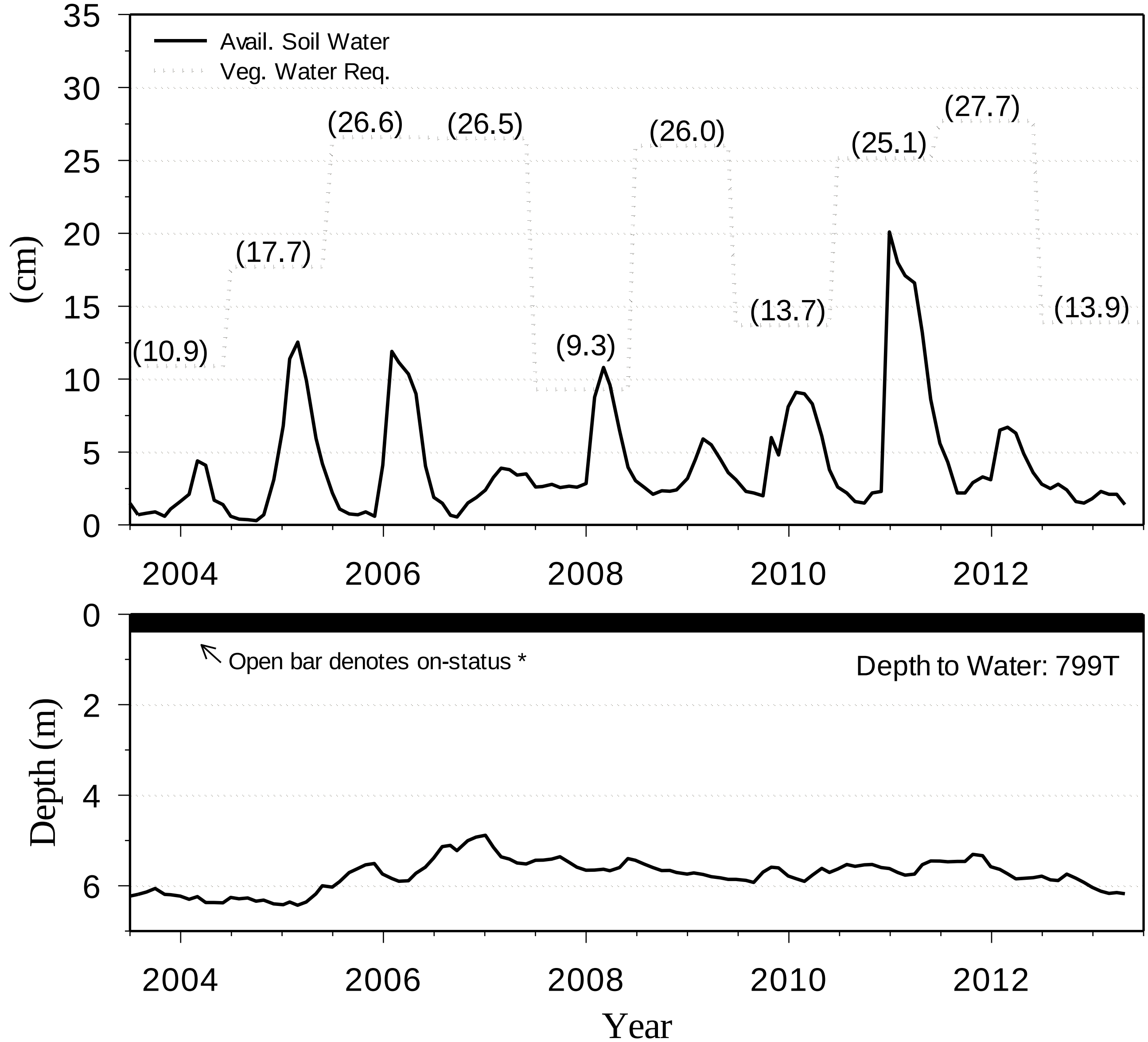
* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 210, 378, 379, 389

Soil water required for turn on (22.9 cm)

BIG PINE MONITORING SITE #2

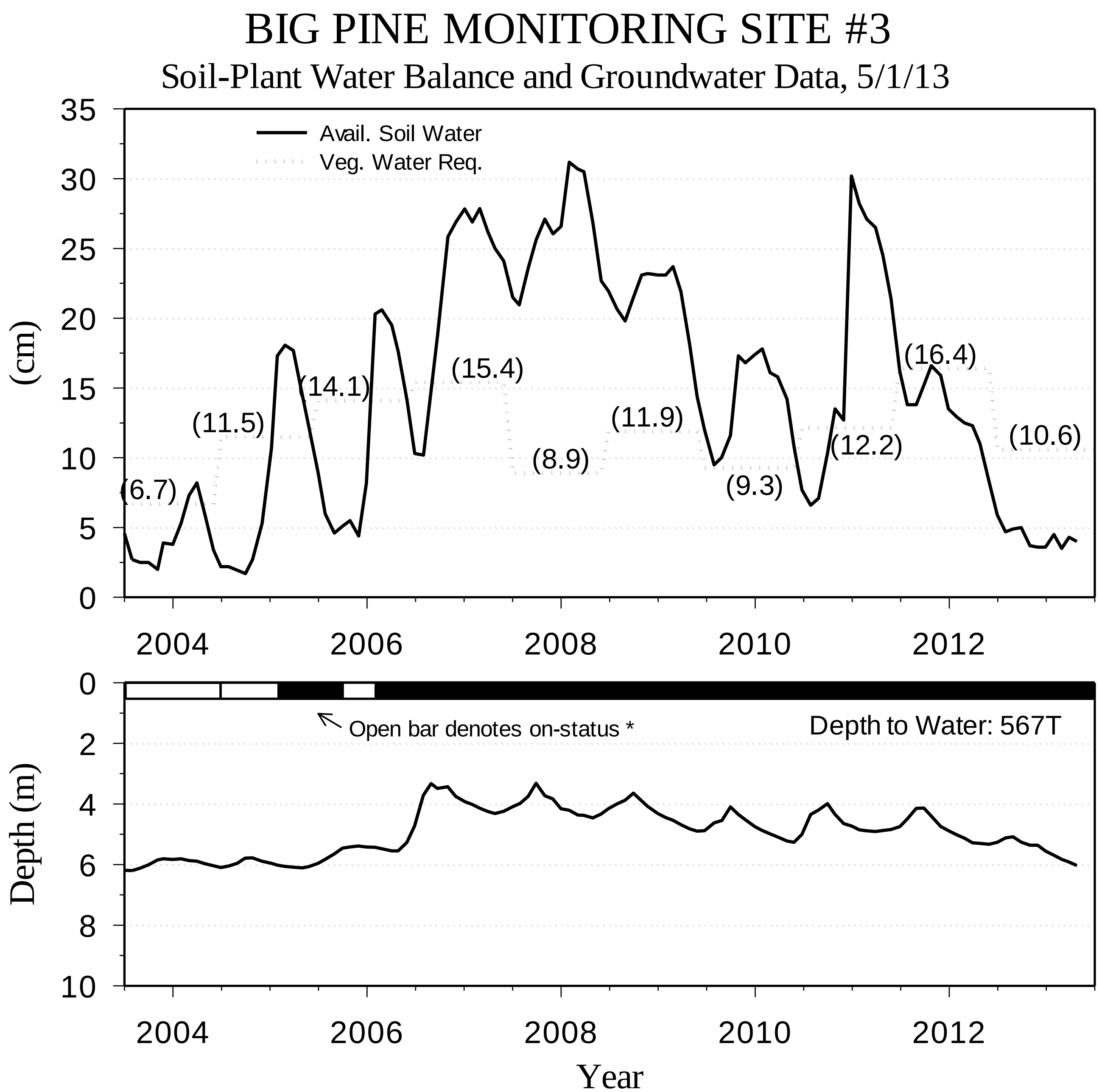
Soil-Plant Water Balance and Groundwater Data, 5/1/13



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 220, 229, 374, 375

Soil water required for turn on (28.4 cm)



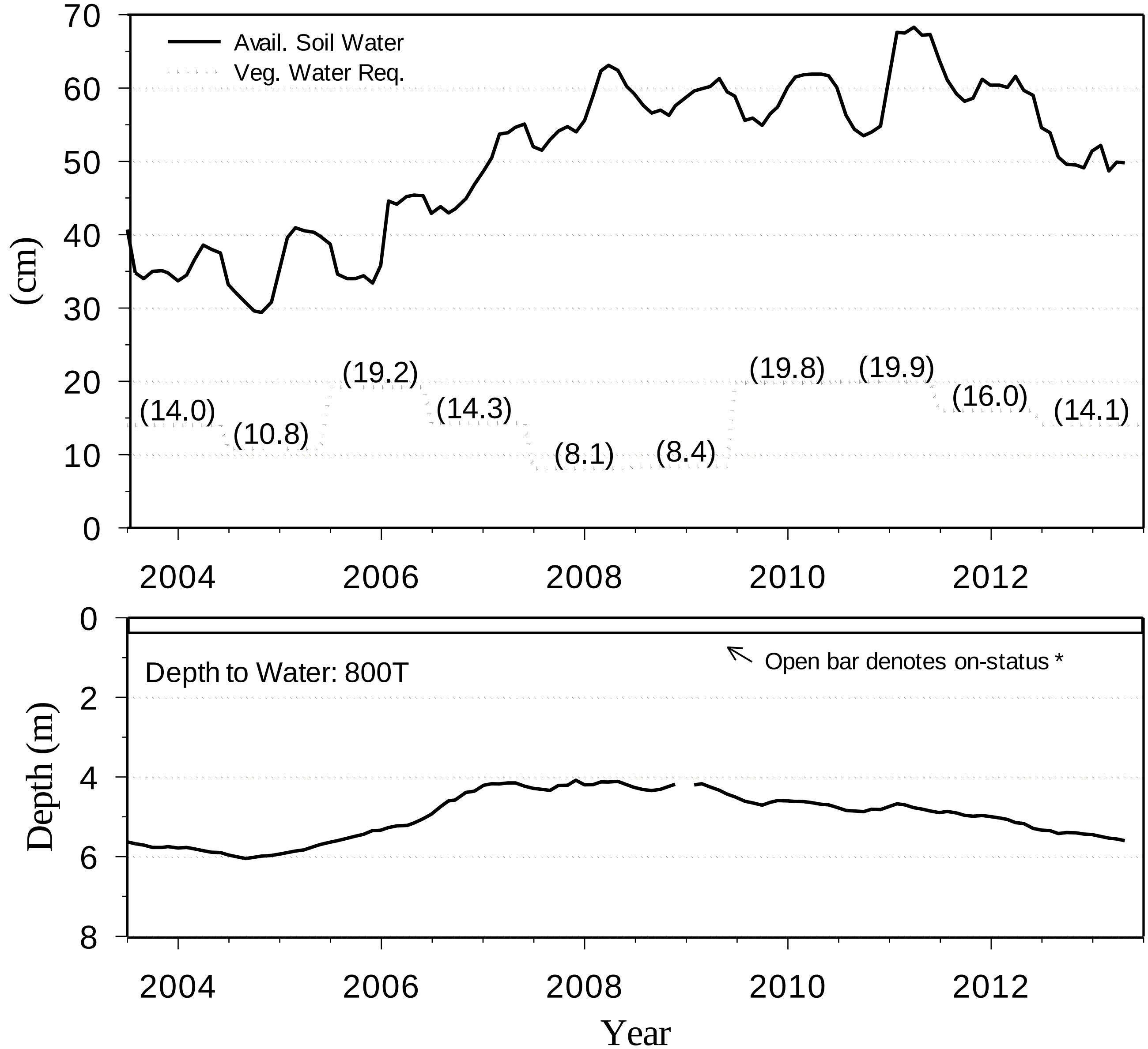
* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 222, 223, 231, 232

Soil water required for turn on (10.6 cm)

BIG PINE MONITORING SITE #4

Soil-Plant Water Balance and Groundwater Data, 5/1/13



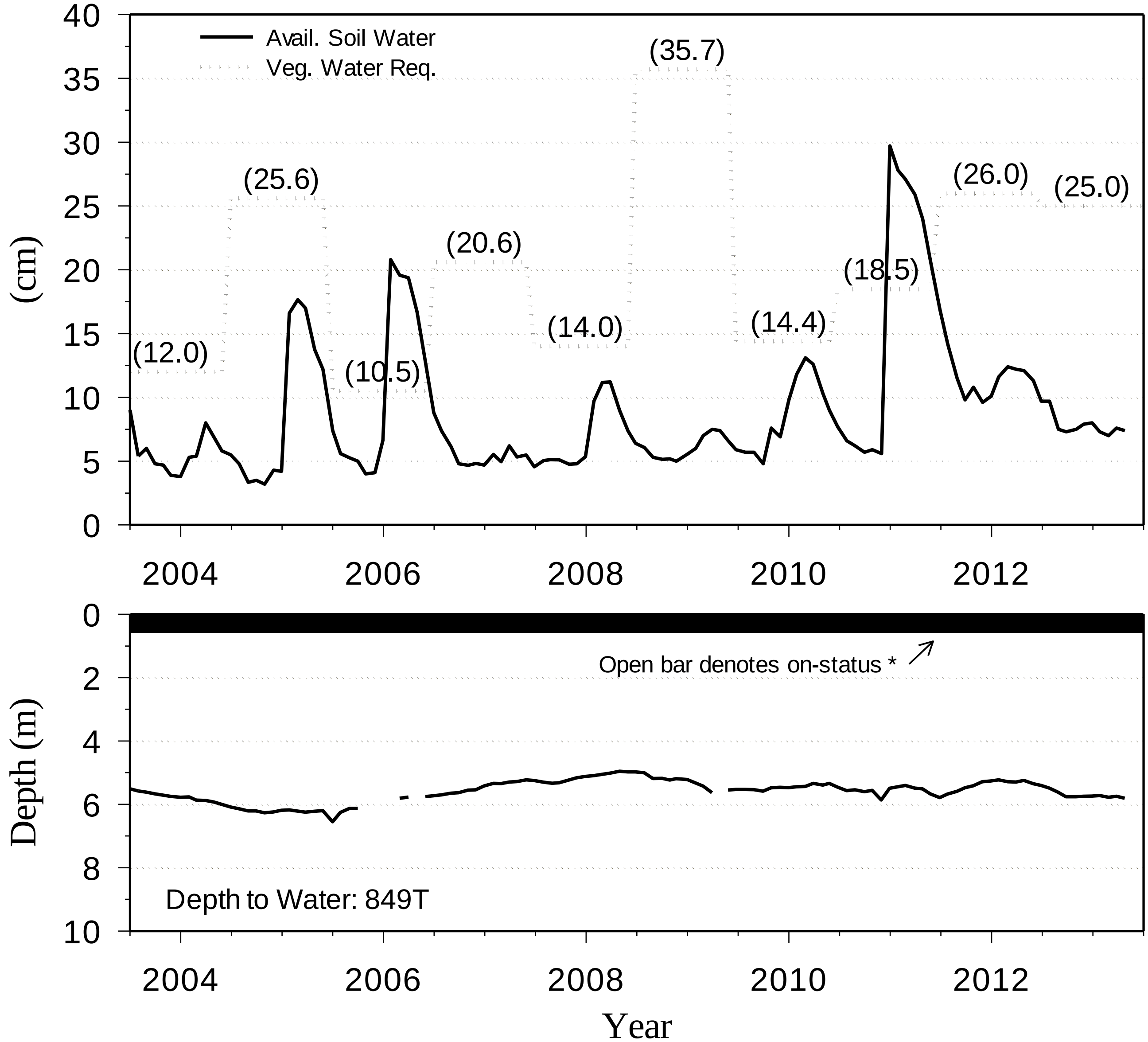
* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping well - 331

Soil water required for turn on (--)

TABOOSE/ABERDEEN MONITORING SITE #3

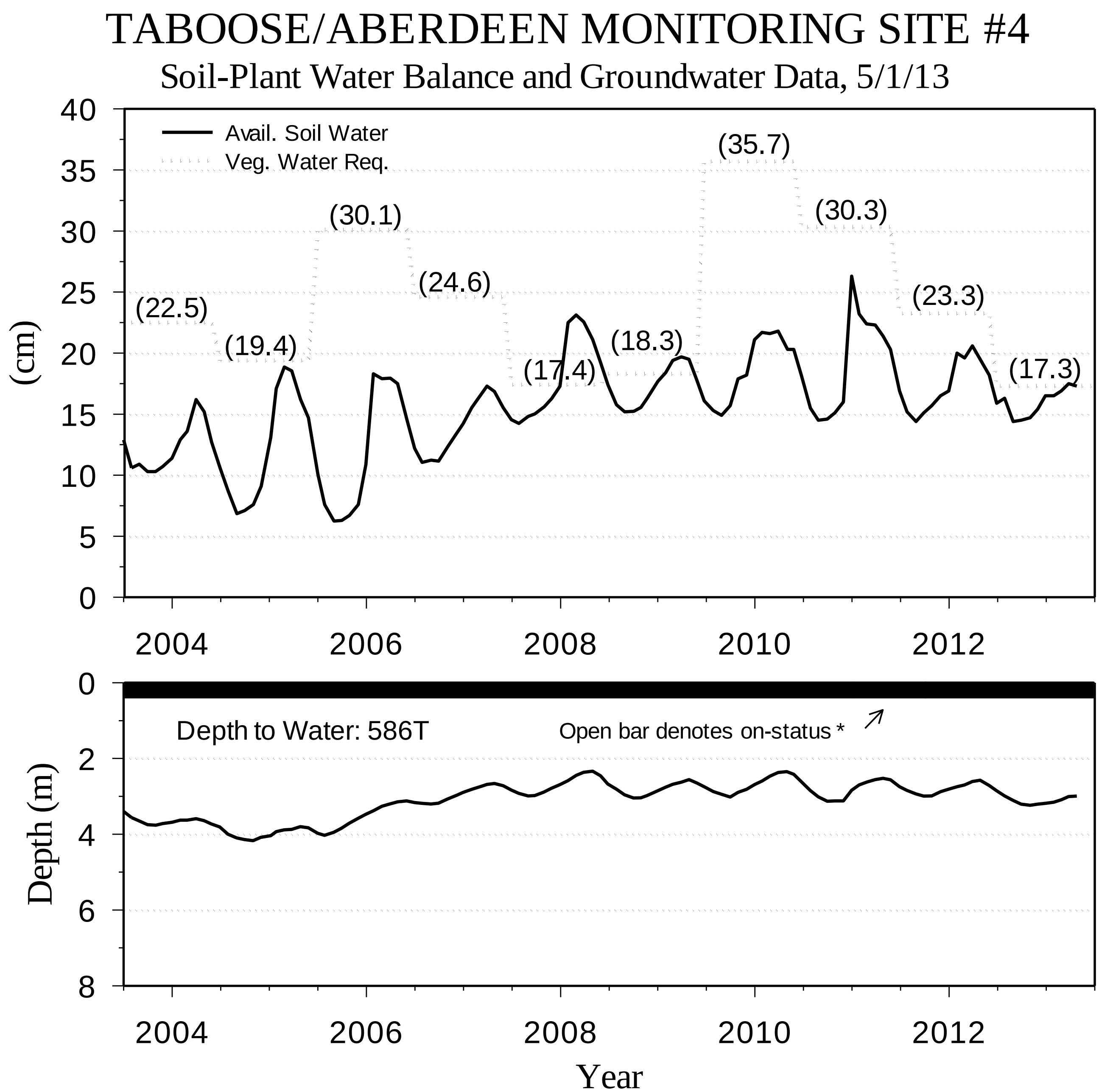
Soil-Plant Water Balance and Groundwater Data, 5/1/13



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 106, 110, 111, 114

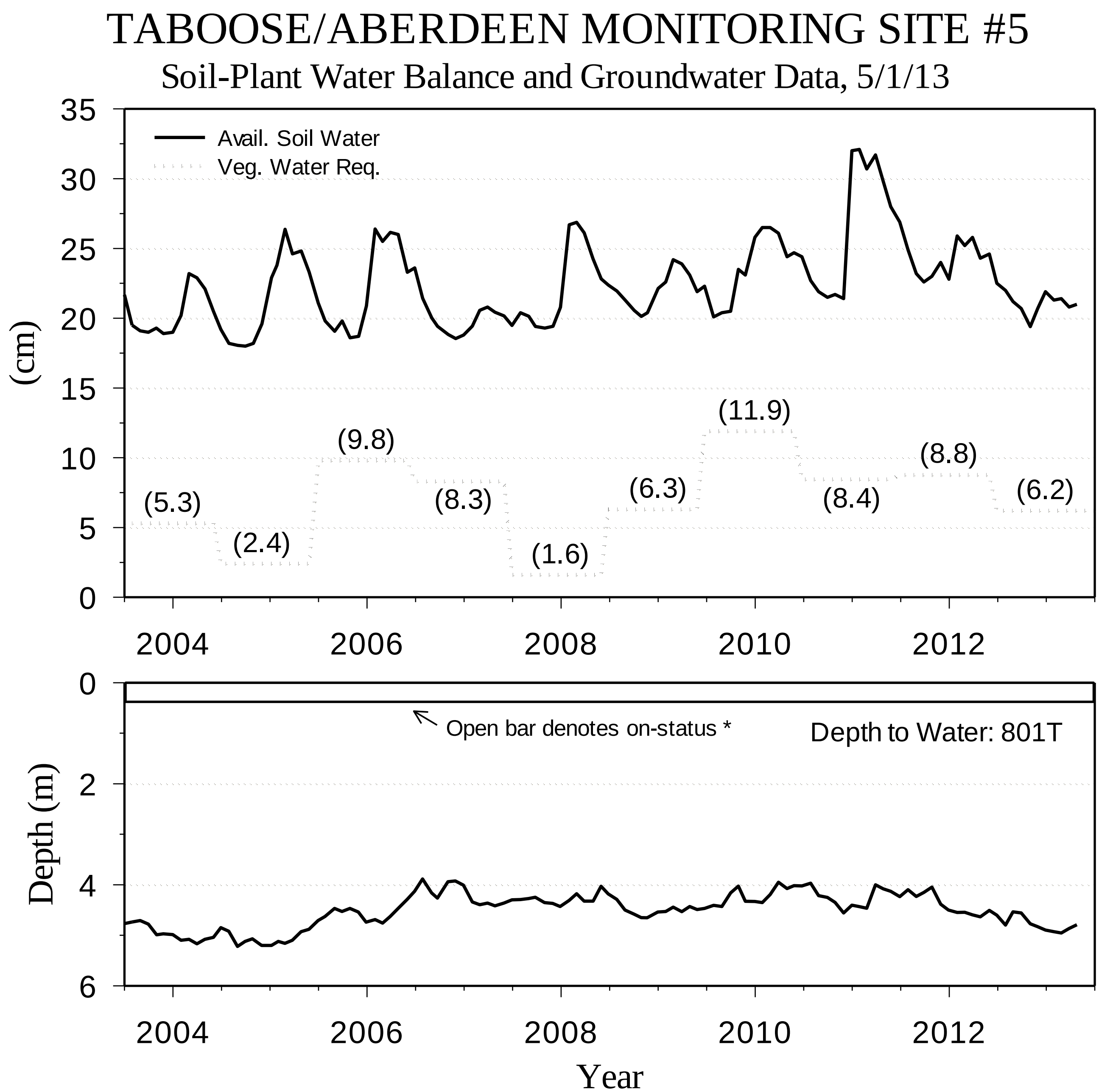
Soil water required for turn on (26.0 cm)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 342, 347

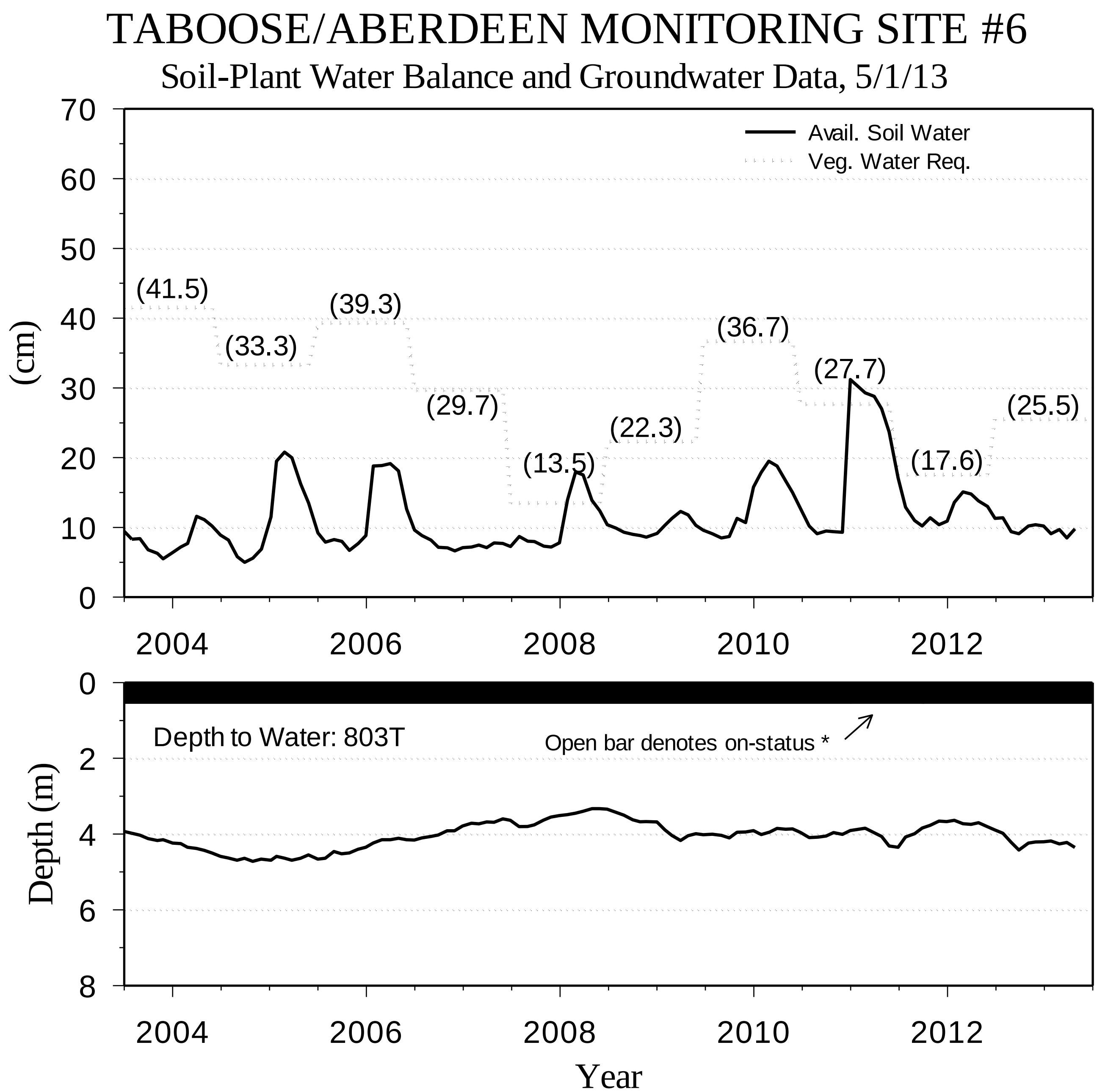
Soil water required for turn on (23.3 cm)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III value for Veg. Water Req.

Linked pumping well - 349

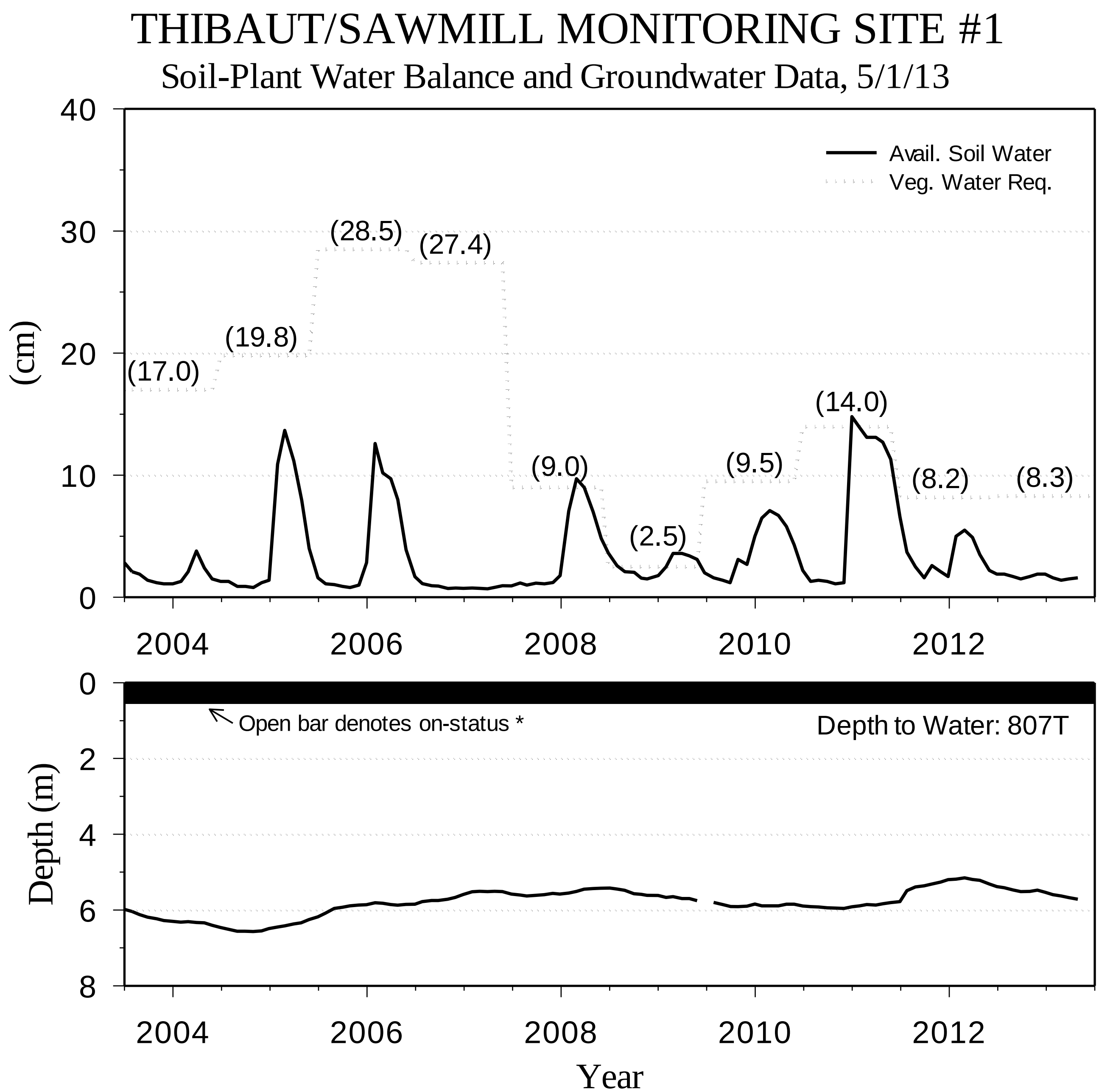
Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to Green Book Section III values for Veg. Water Req.

Linked pumping wells - 109, 370

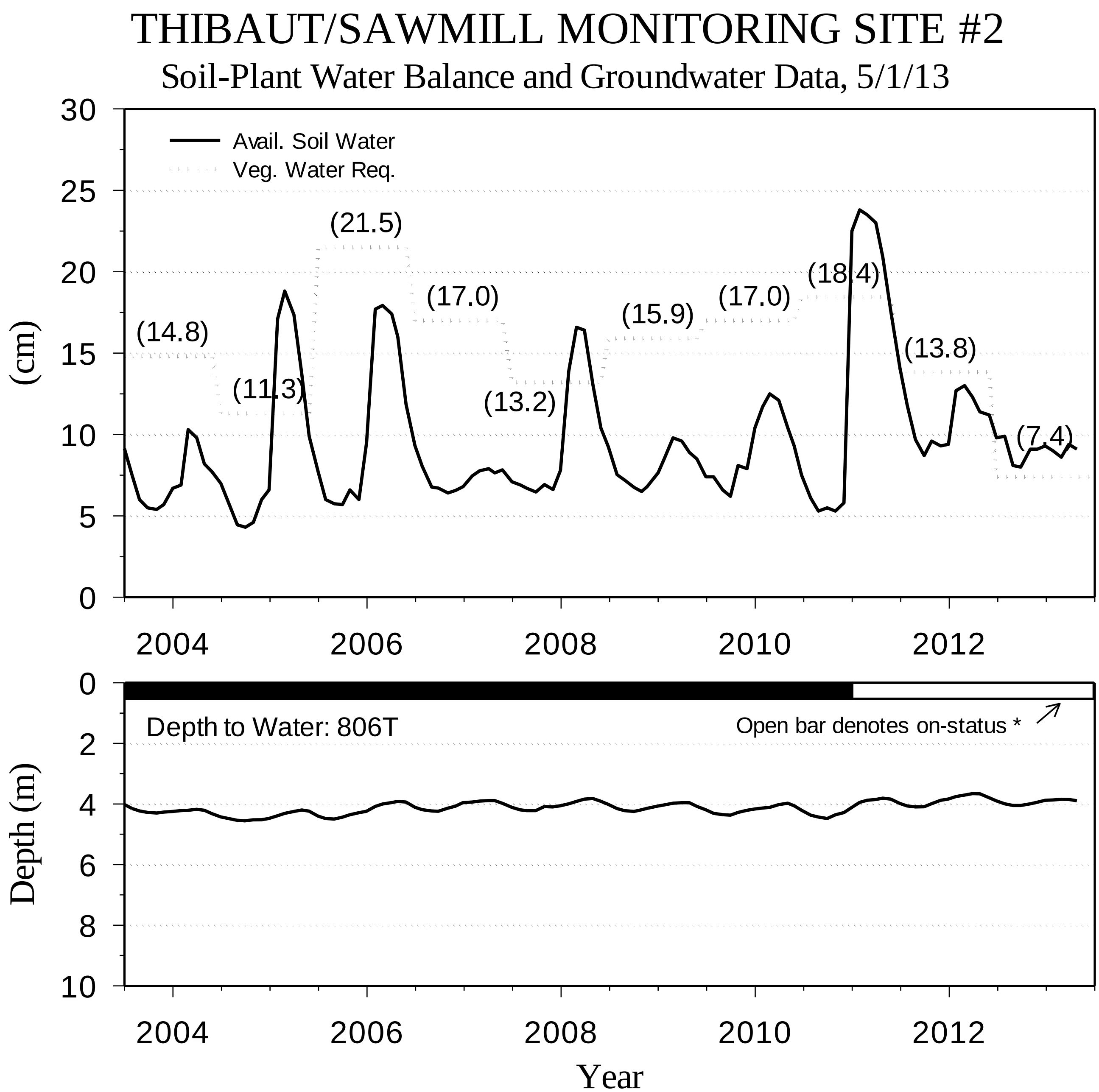
Soil water required for turn on (17.6 cm)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping well - 159

Soil water required for turn on (20.4 cm)



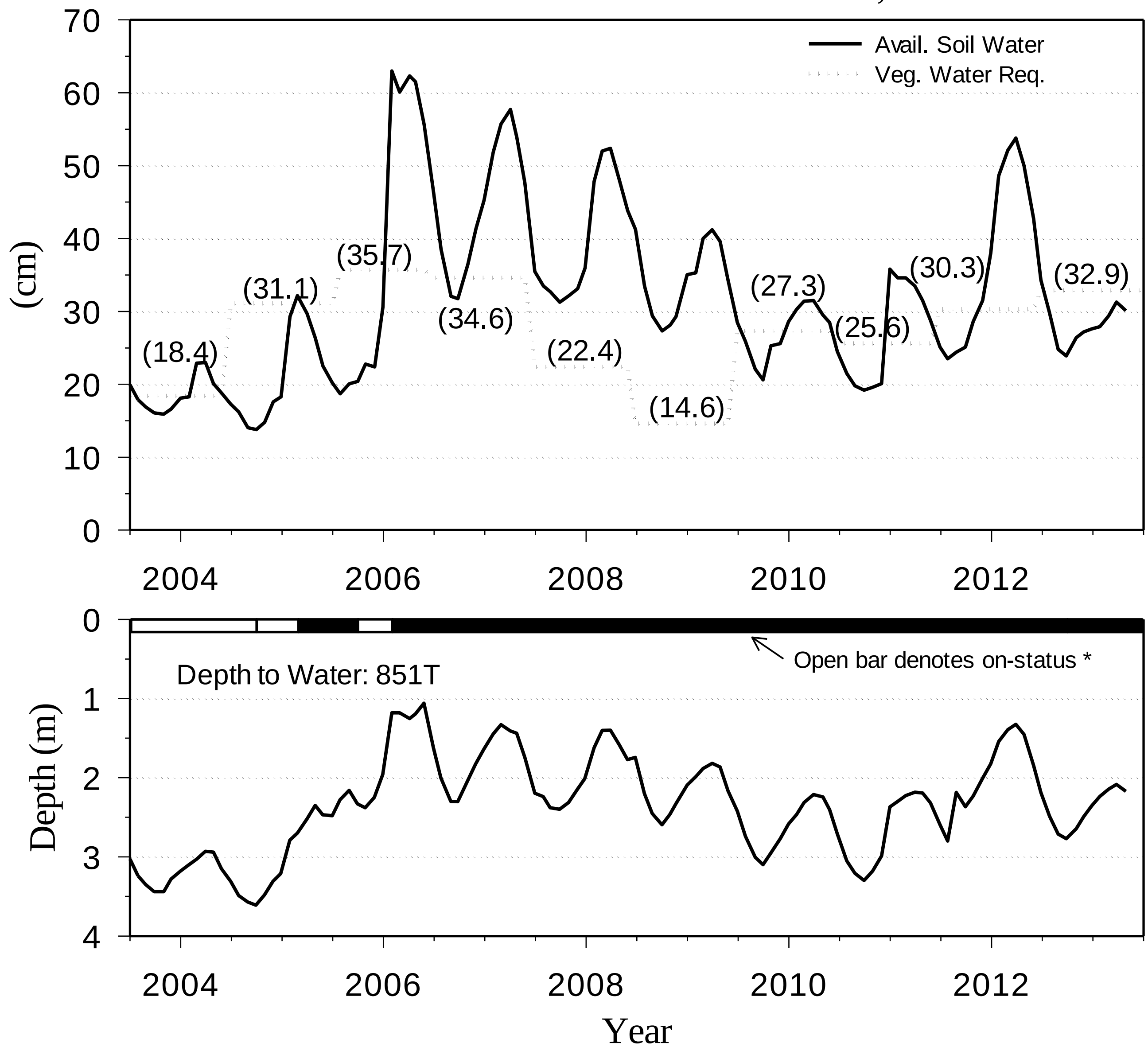
* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping well - 155

Soil water required for turn on (--)

THIBAUT/SAWMILL MONITORING SITE #3

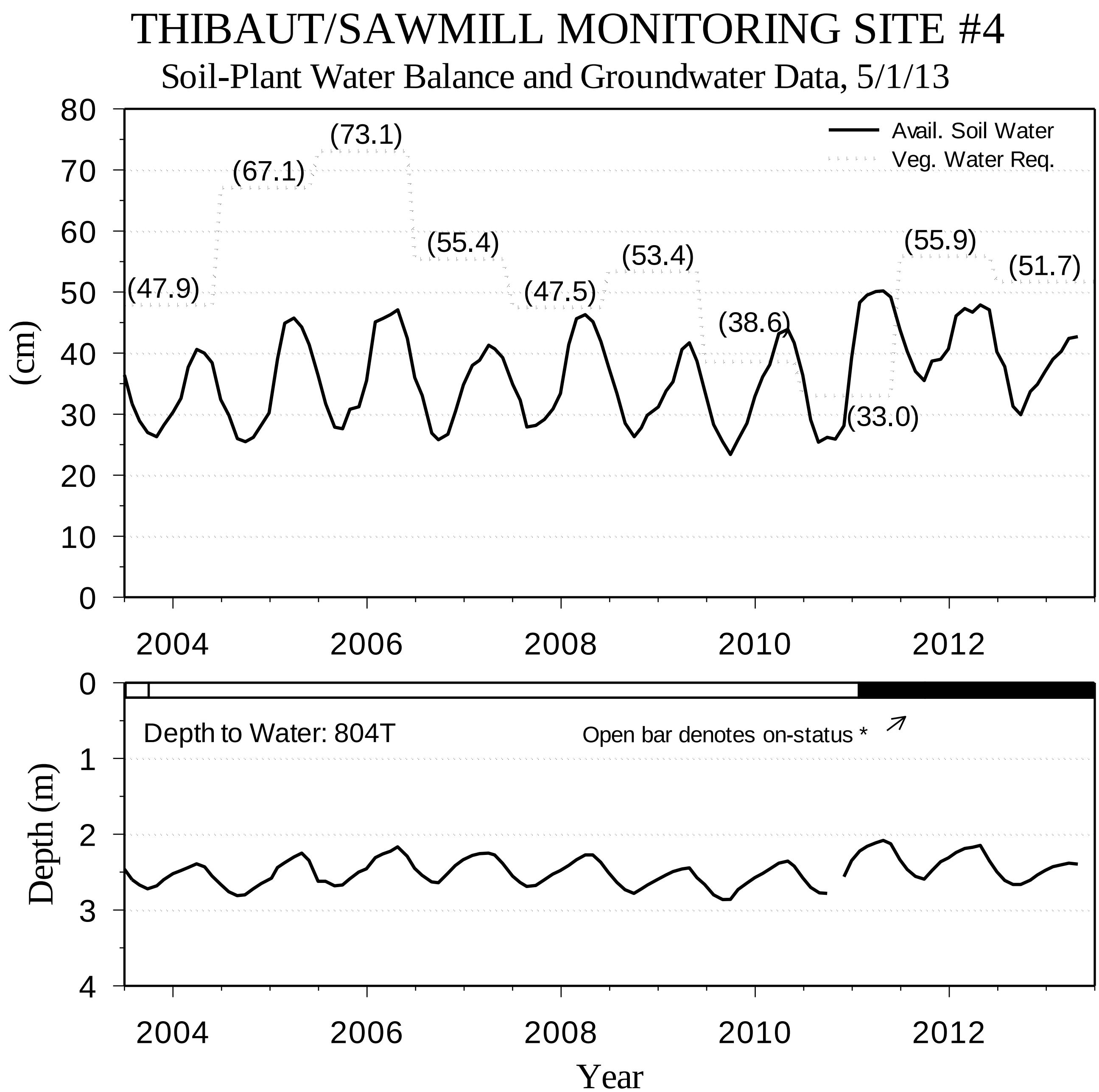
Soil-Plant Water Balance and Groundwater Data, 5/1/13



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 103, 104, 382

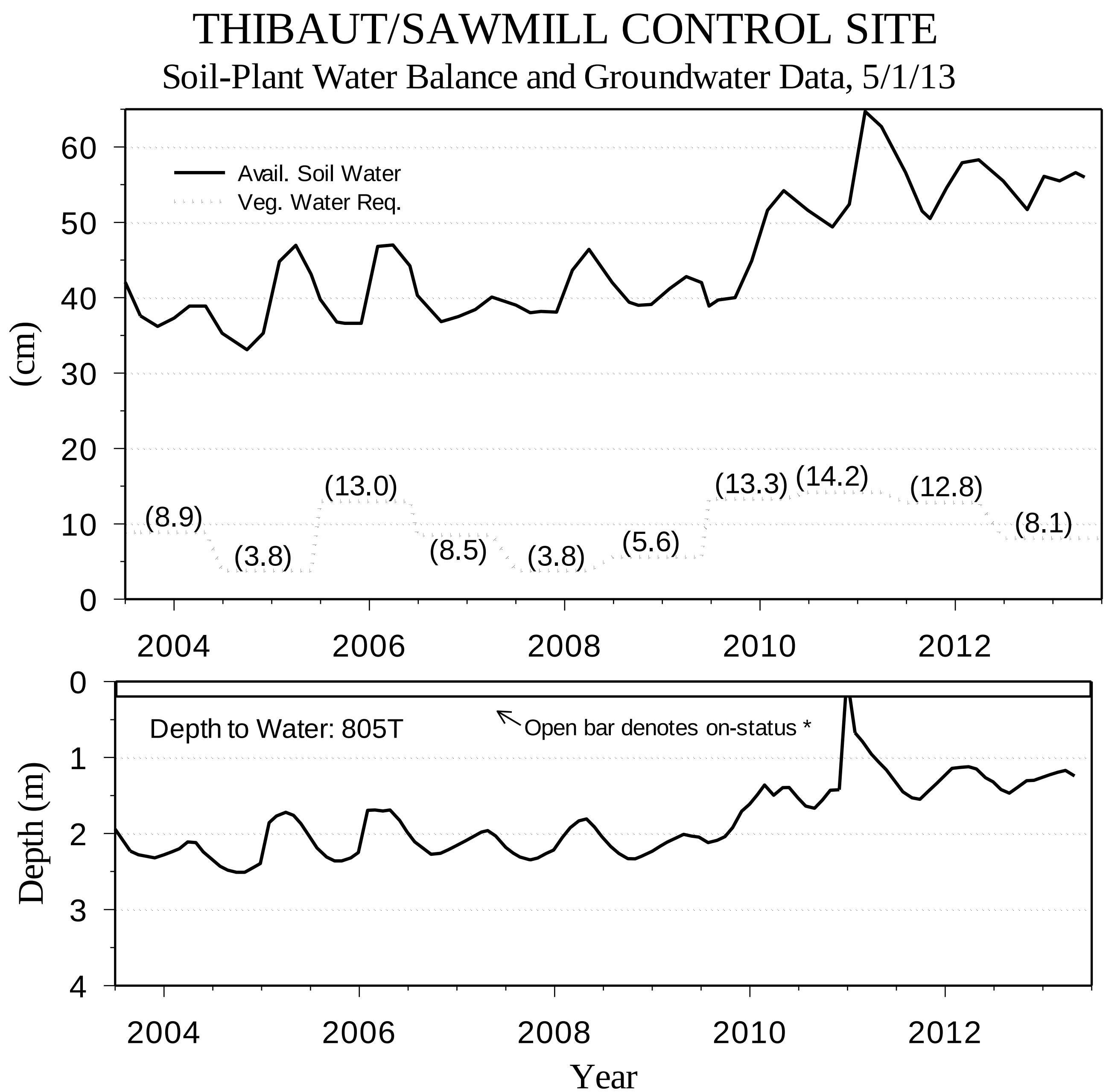
Soil water required for turn on (32.9 cm)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 380, 381

Soil water required for turn on (55.9 cm)

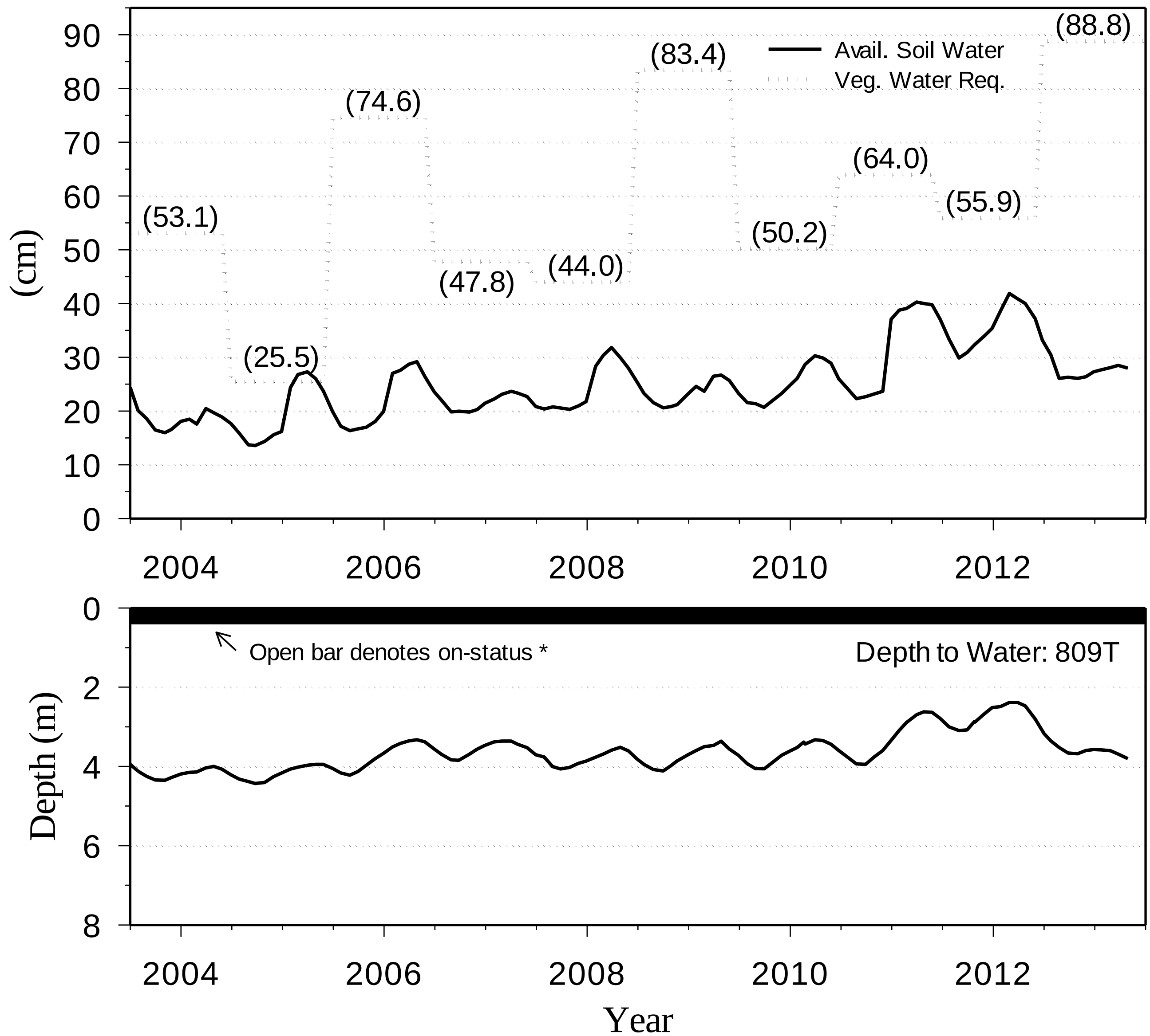


* On\off according to the Green Book Section III values for Veg. Water Req.

Soil water required for turn on (--)

INDEPENDENCE/OAK MONITORING SITE #1

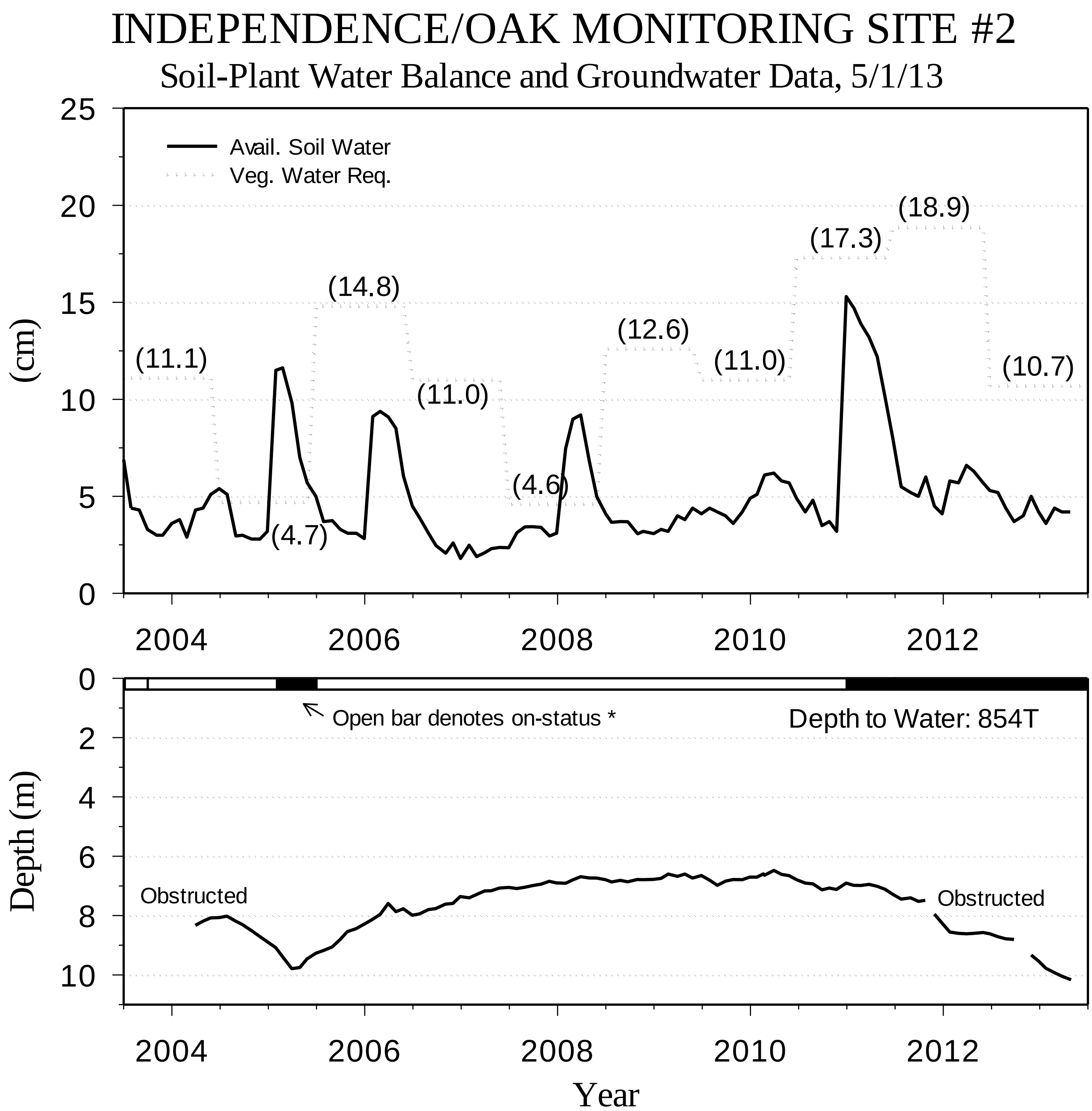
Soil-Plant Water Balance and Groundwater Data, 5/1/13



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 61, 391, 400

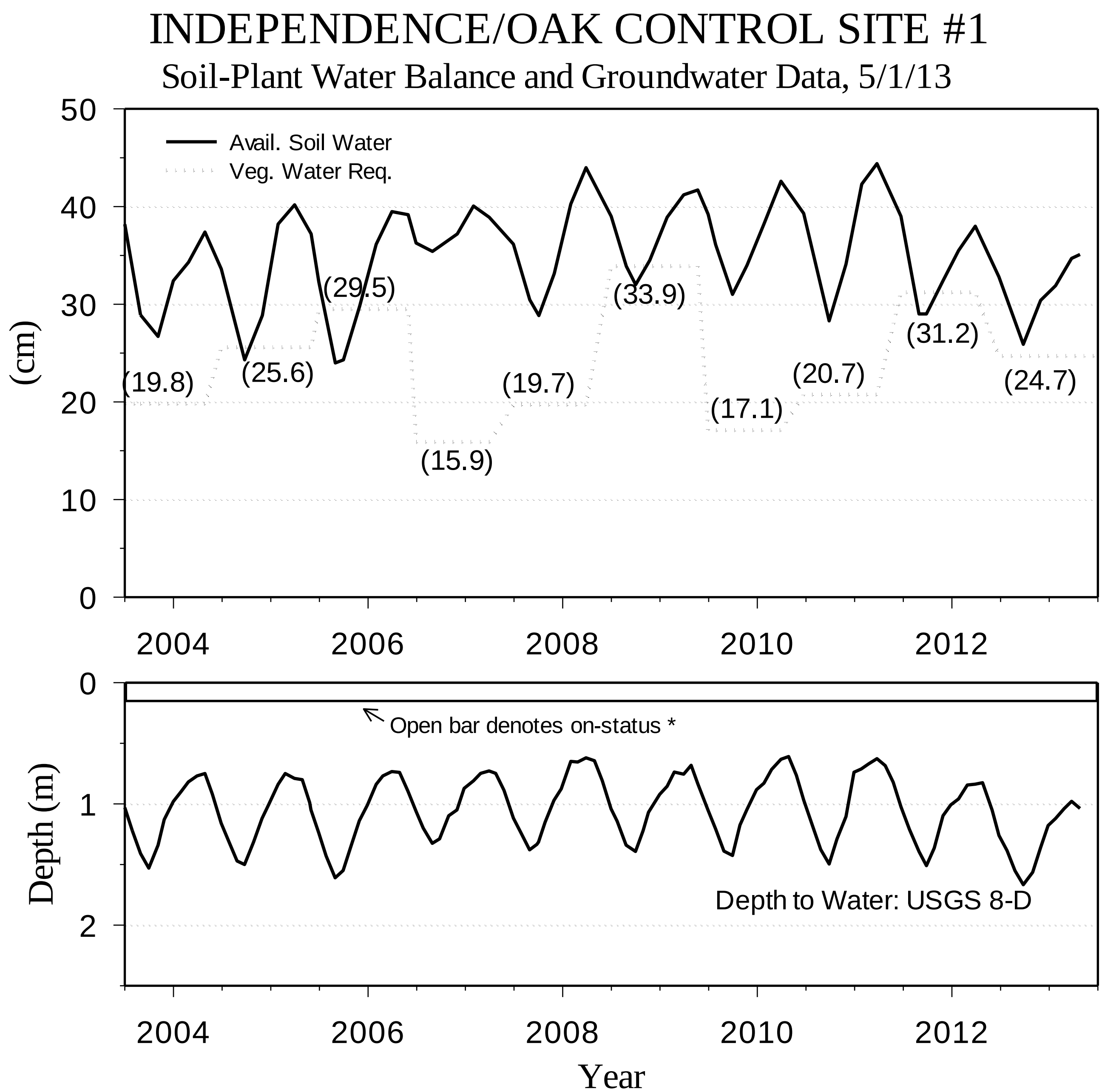
Soil water required for turn on (42.2 cm)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

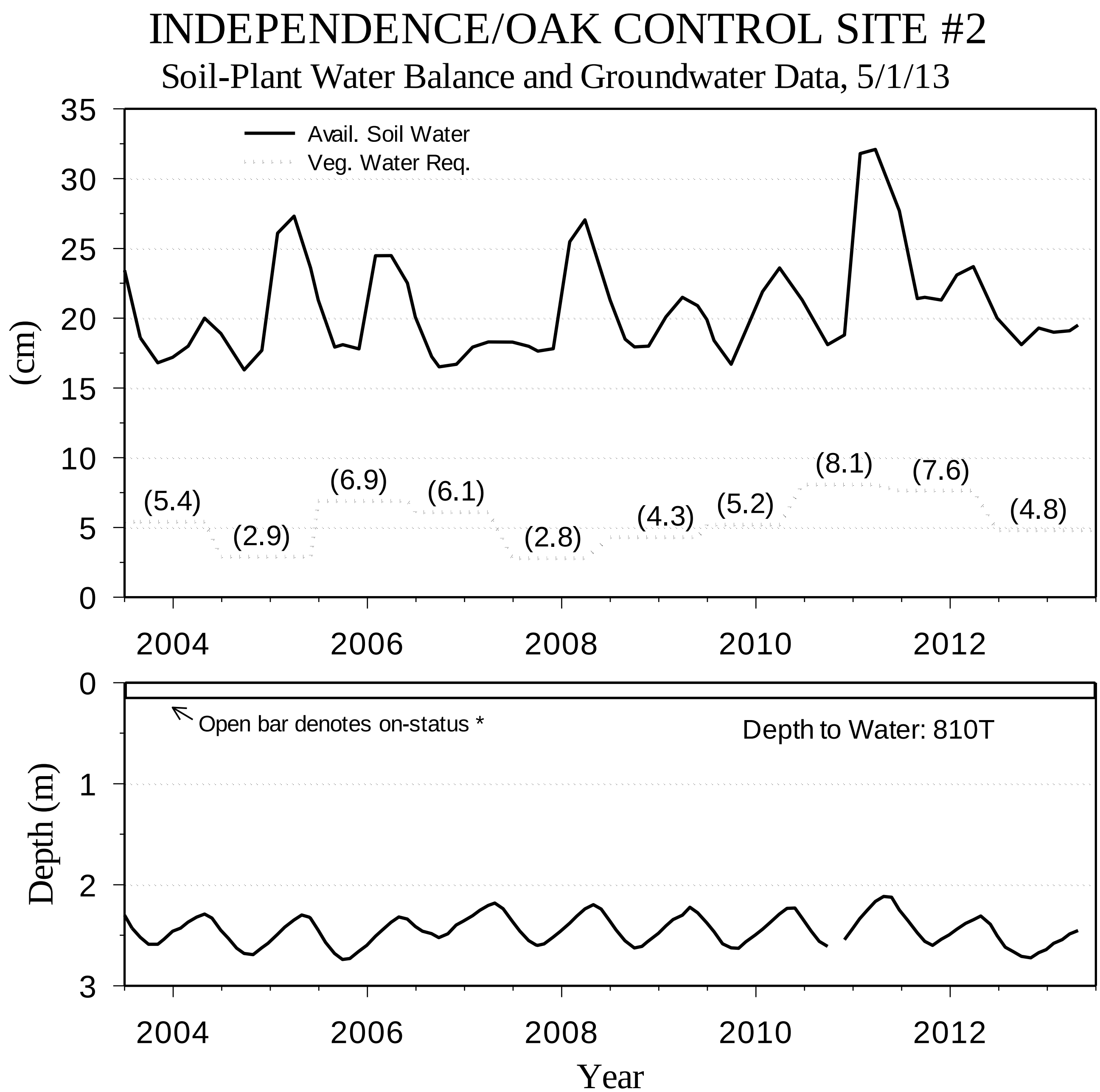
Linked pumping well - 63

Soil water required for turn on (18.9 cm)



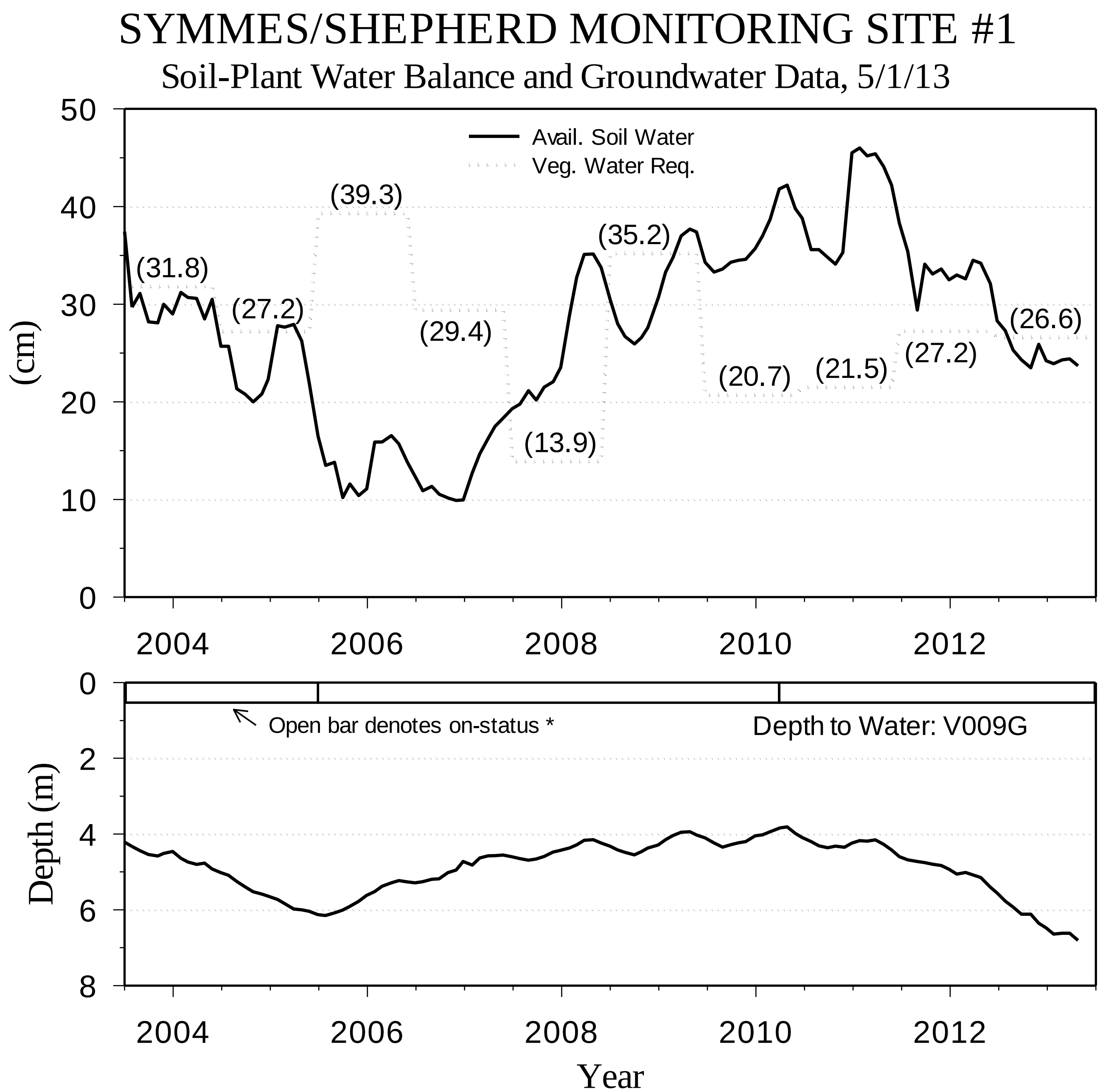
* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

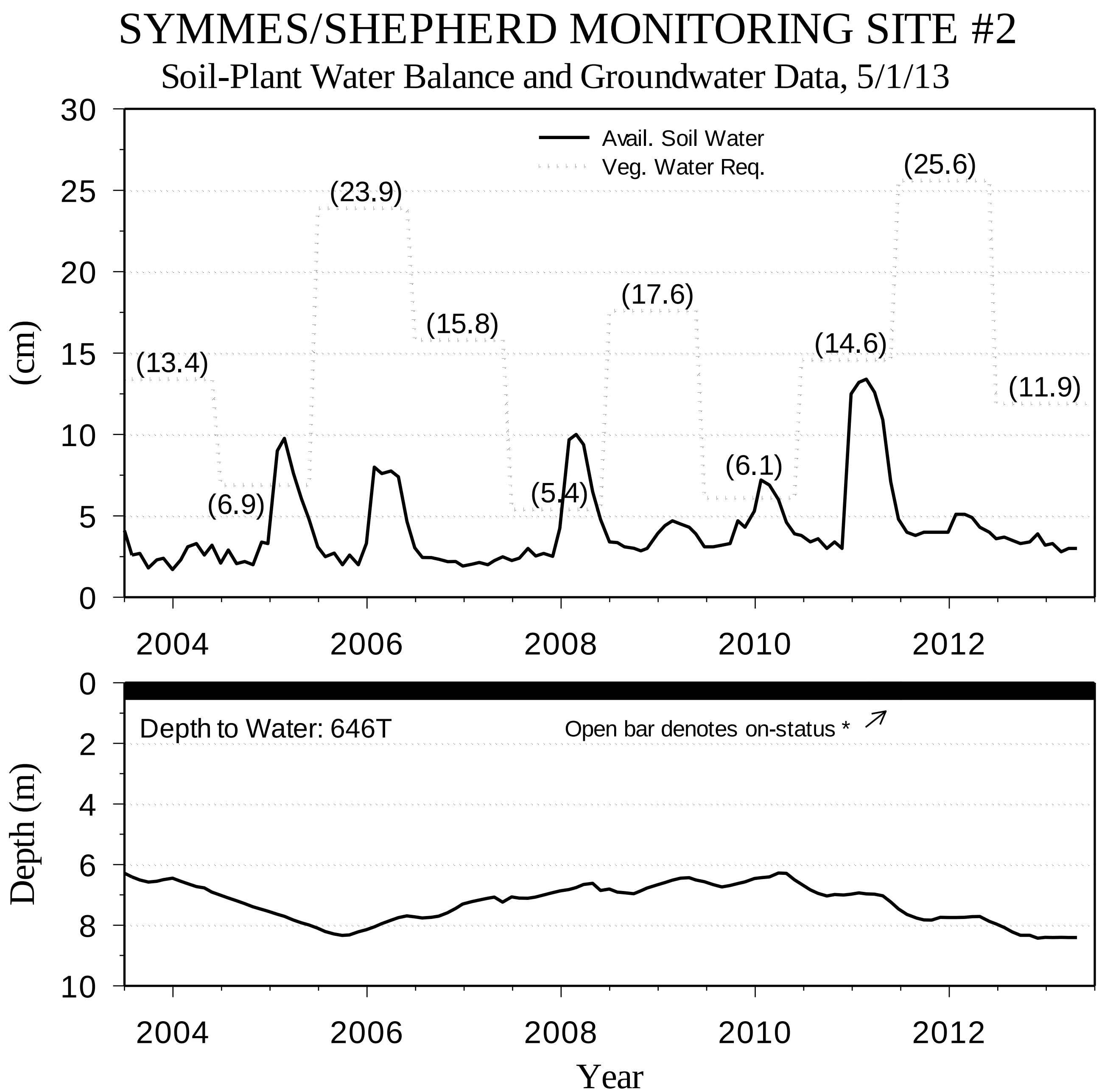
Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 69, 392, 393

Soil water required for turn on (--)



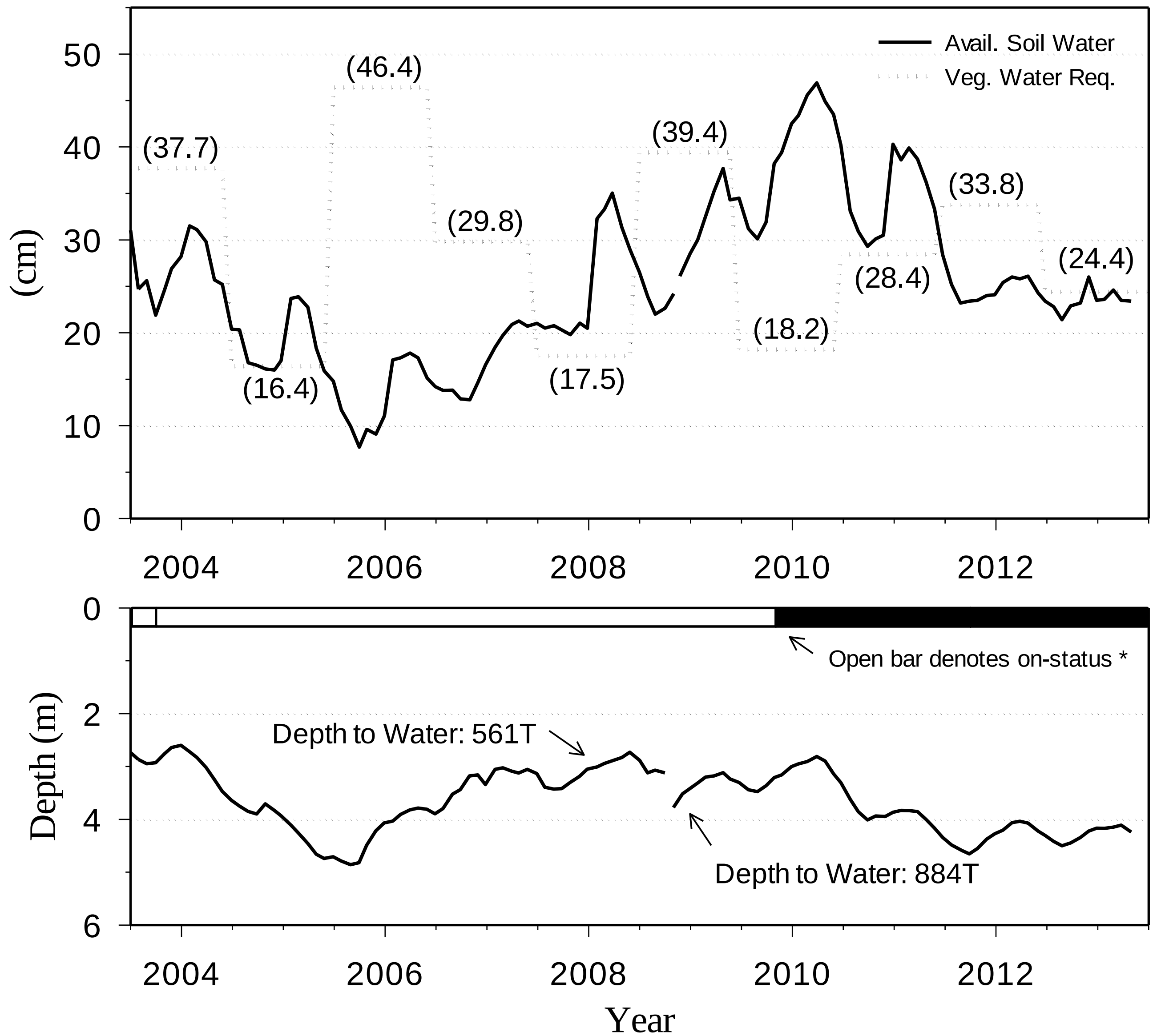
* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 74, 394, 395

Soil water required for turn on (25.6 cm)

SYMMES/SHEPHERD MONITORING SITE #3

Soil-Plant Water Balance and Groundwater Data, 5/1/13

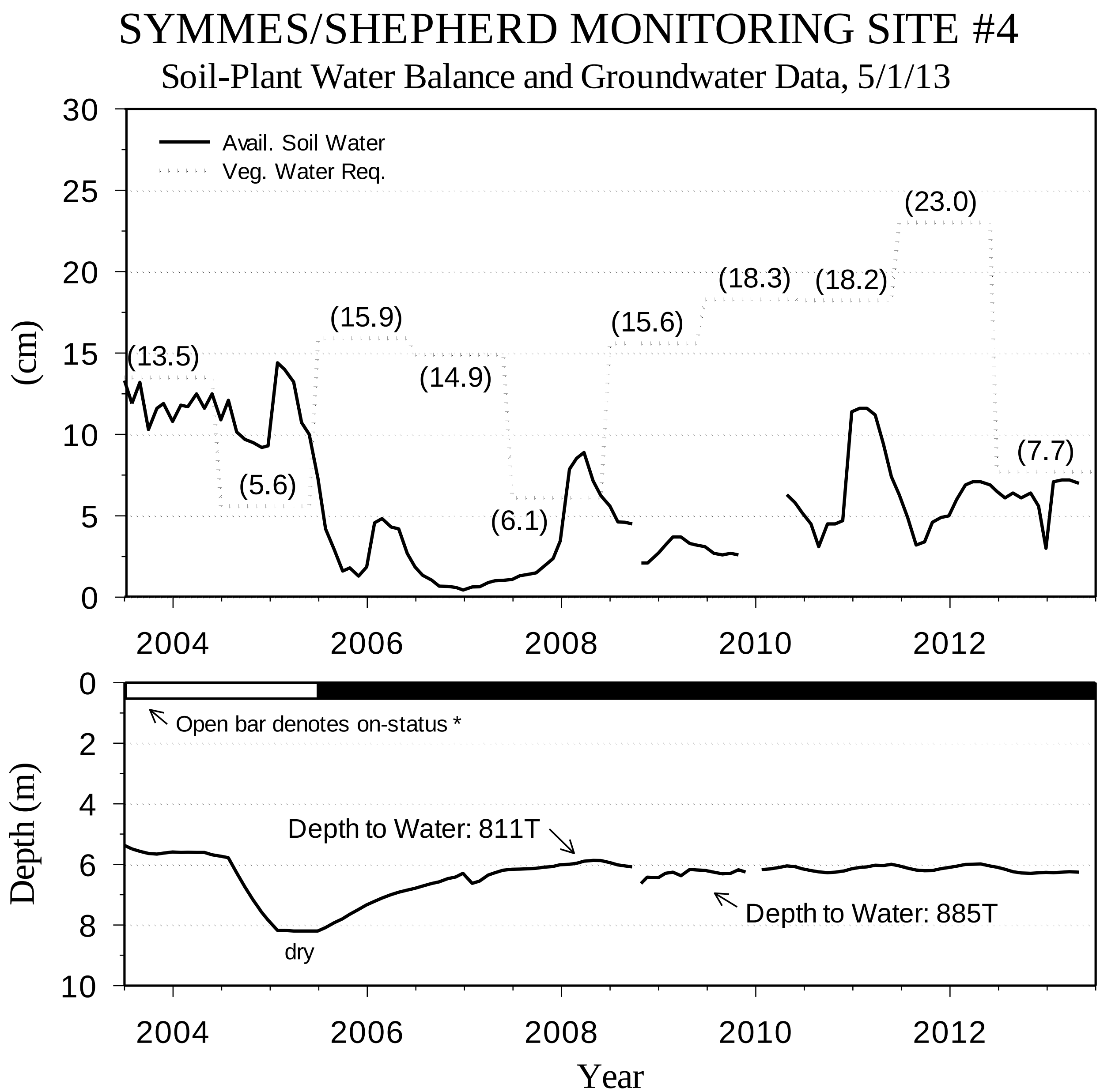


* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 92, 396

Soil water required for turn on (33.8 cm)

New soil water monitoring locations established Dec 1, 2008

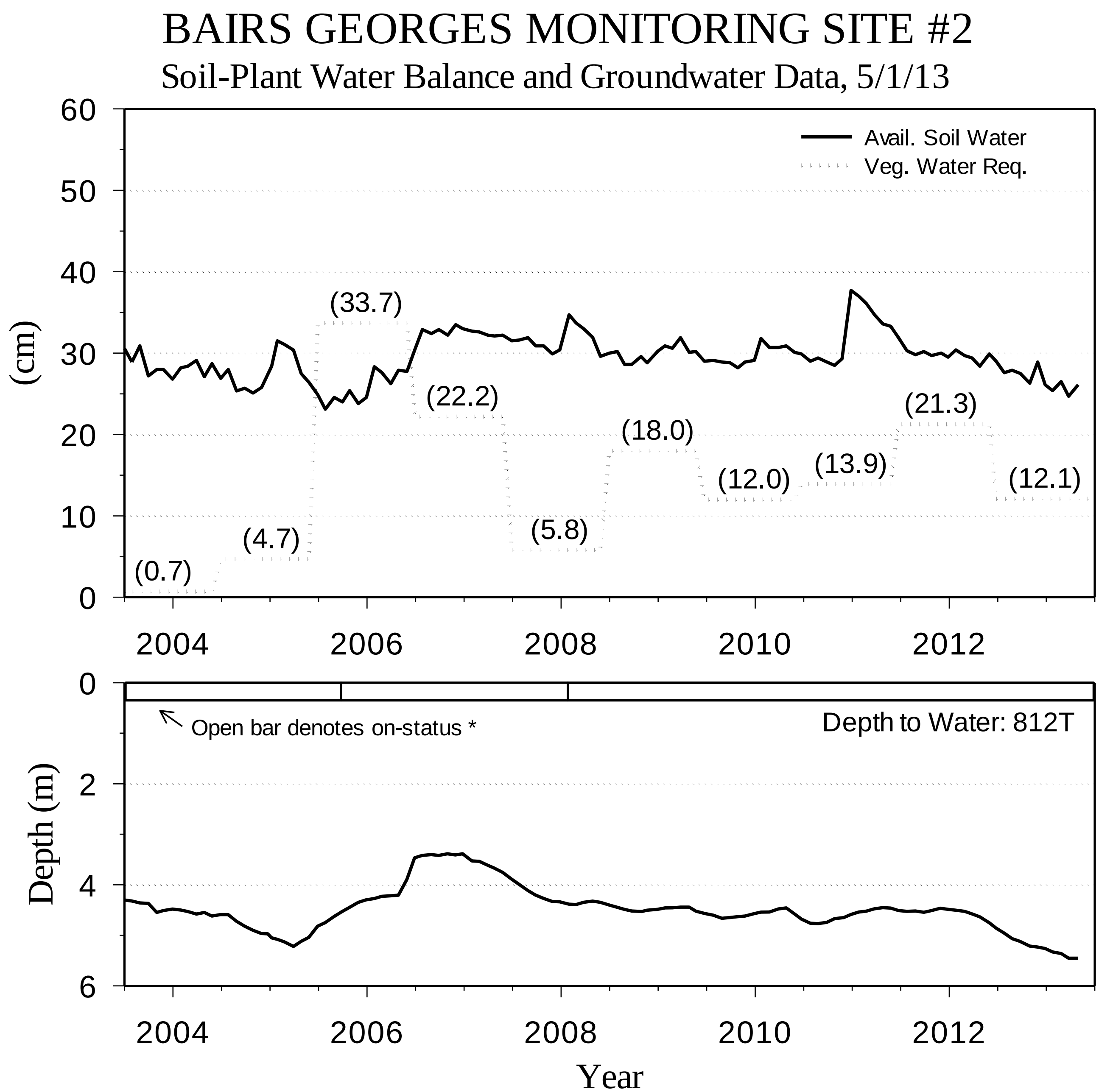


* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 75, 345

Soil water required for turn on (15.9 cm)

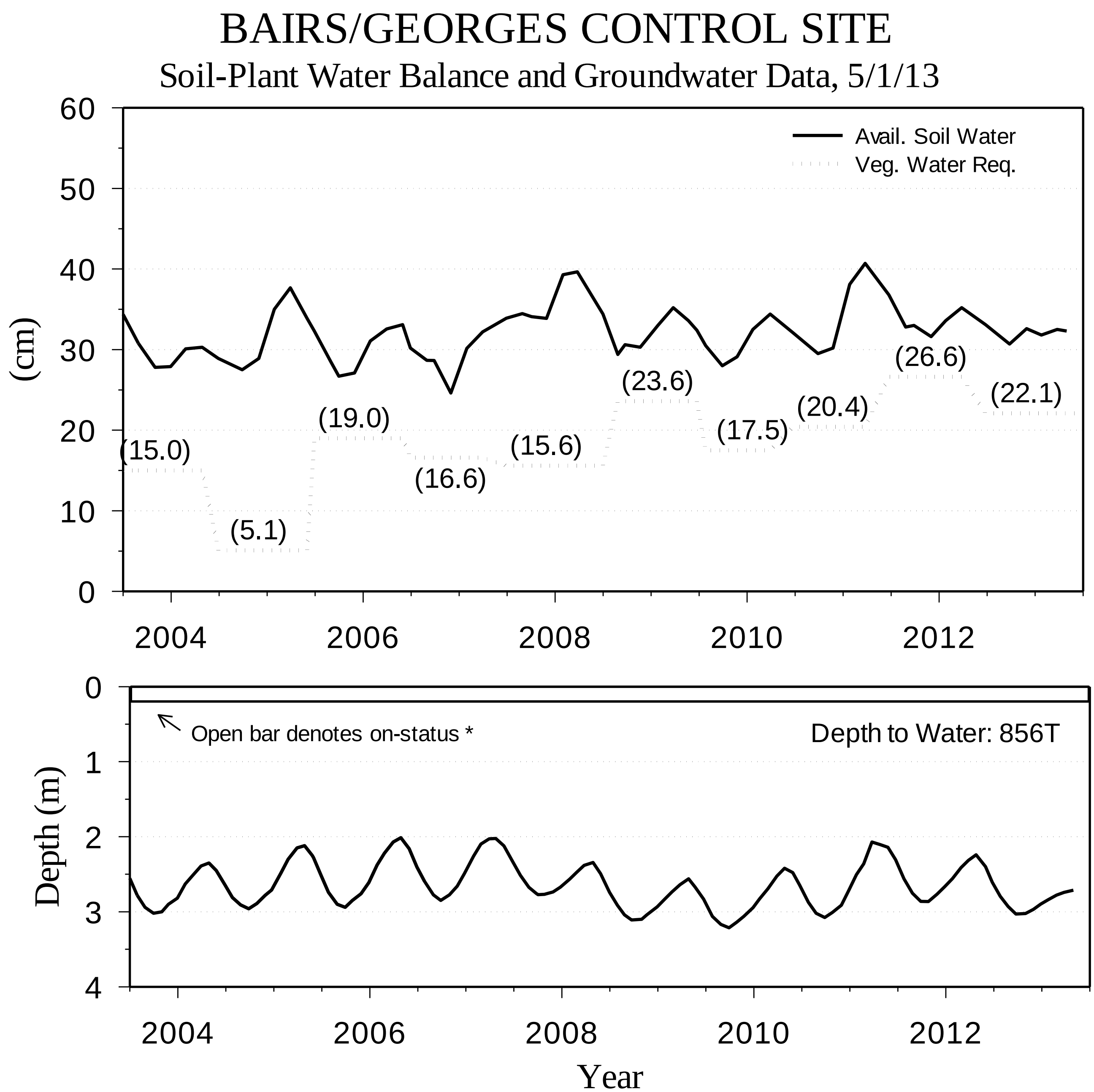
New soil water monitoring locations established Nov 1, 2008 and May 1, 2010



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Linked pumping wells - 76, 403, 343, 348

Soil water required for turn on (--)



* Wells not necessarily operated when in on-status. On\off according to the Green Book Section III values for Veg. Water Req.

Soil water required for turn on (--)

SECTION 5: SALTCEDAR CONTROL PROGRAM

The goal of the Saltcedar Control Program is to eliminate existing saltcedar stands and prevent the spread of saltcedar throughout the Lower Owens River and associated wetlands to support the habitat restoration that is occurring in the LORP.

The goal of the Saltcedar Control Program is to eliminate existing saltcedar stands and prevent the spread of saltcedar throughout the Lower Owens River and associated wetlands to support the habitat restoration that is occurring in the LORP. This section of the 2012-13 ICWD Annual Report briefly describes work completed from October 2012 to April 2013. A more complete description of the progress of the saltcedar program is contained in the Lower Owens River Annual Report.

Program Background

Saltcedar (Tamarix ramosissima) is an invasive non-native shrub or tree that can grow to 25 feet and live up to 100 years. Given favorable conditions, a tree can grow 10 to 12 feet in one season. Saltcedar competes with native vegetation and degrades wildlife habitat. Its presence in the southern Owens Valley has the potential to interfere with the LORP goals of establishing a healthy, functioning Lower Owens River riverine-riparian ecosystem.

References to the importance of managing saltcedar can be found in documents that guide the saltcedar program and govern the LORP:

- The LORP Monitoring, Adaptive Management, and Reporting Plan (MAMP), notes that saltcedar may increase in some areas of the river because of seed distribution with stream flows. The MAMP states that the potential risk of infecting new areas with saltcedar is considered a significant threat in all management areas.

- The 1997 Memorandum of Understanding (MOU), between Inyo County, City of Los Angeles, Sierra Club, Owens Valley Committee, CA Dept. of Fish and Game and California State Lands Commission, expresses that saltcedar reinfestation in the LORP area would compromise the goal of controlling deleterious species whose “presence within the Planning Area interferes with the achievement of the goals of the LORP” (1997 MOU B. 4)

- Parties to the Inyo/Los Angeles Long-Term Water Agreement (LTWA) recognized that even with annual control efforts saltcedar might never be fully eradicated, but that ongoing and aggressive efforts to remove saltcedar will be required. (Sec. XIV. A).

Project Management & Staff

The Saltcedar Control Program was created by the Agreement and is administered by the Inyo County Water Department, and managed by a Saltcedar Project Manager. Work crews are hired seasonally and consist of eight employees and one shared county employee. In addition, the California Department of Forestry and Fire Protection (Cal Fire) has provided work crews to assist in efforts to cut saltcedar and remove slash. In 2012-2013, the field season began in-October and concluded in mid-April.

Methods

The Saltcedar Control Program uses chainsaws, brushcutters, herbicides, and fire to treat and control saltcedar, and saltcedar slash in the Owens Valley.

Work Accomplished

In 2012, work focused on eradicating saltcedar in the water-spreading basins that lie just to the west of the Lower Owens River and river-riparian area. These spreading basins are a concern because they harbor mature saltcedar thickets that function as seed sources for possible re-establishment of saltcedar within the LORP riparian corridor. The program cut and treated 200 acres in these spreading basins (Figure 5.1).

Surveying the river to locate and remove saltcedar is an annual and ongoing activity by ICWD and LADWP staff. Treating saltcedar in the LORP riparian area and especially new established plants is a priority of the Saltcedar program. At various times during the cutting season over the winter, crews worked along the river to treat resprouts and pull seedlings recorded the previous summer along the 89 miles of LORP river bank and floodplain. In addition, many mature plants that were discovered in the process of clearing the river were also treated.

Extensive saltcedar treatment in recent years has resulted in large amounts of woody slash accumulation on the landscape. Inyo County and Los Angeles reached agreement in 2012 on a slash treatment plan prepared by the ICWD. The preferred treatment method was stacking and burning slash. Following acquisition of required burn permits, in April 2012 the ICWD conducted test burns on several piles in spreading basins. The necessary equipment to provide the required water supply at burn sites was purchased during the intervening summer, and a more aggressive burn program began in the fall after burn restrictions were lifted. About 660 piles of slash were burned during the 2012-13 field season by the Saltcedar Program crews and CalFire (Figure 5.1).

Funding

Funding for the Saltcedar program comes from the Water Agreement and grants from the California Wildlife Conservation Board (WCB). The Water Agreement provided $69,481. The Inyo County Water Department was awarded a new grant from the WCB for $385,000 in December 2011. LADWP has assisted the County in its efforts to renew the WCB grant and matched the grant fulfilling their obligation under the 2004 Stipulation and Order to match up to $1,500,000 of any grant funds obtained by the County. In addition, LADWP provided the annual funding required by the Water Agreement. The 2012-13 program relied on these three funding sources.

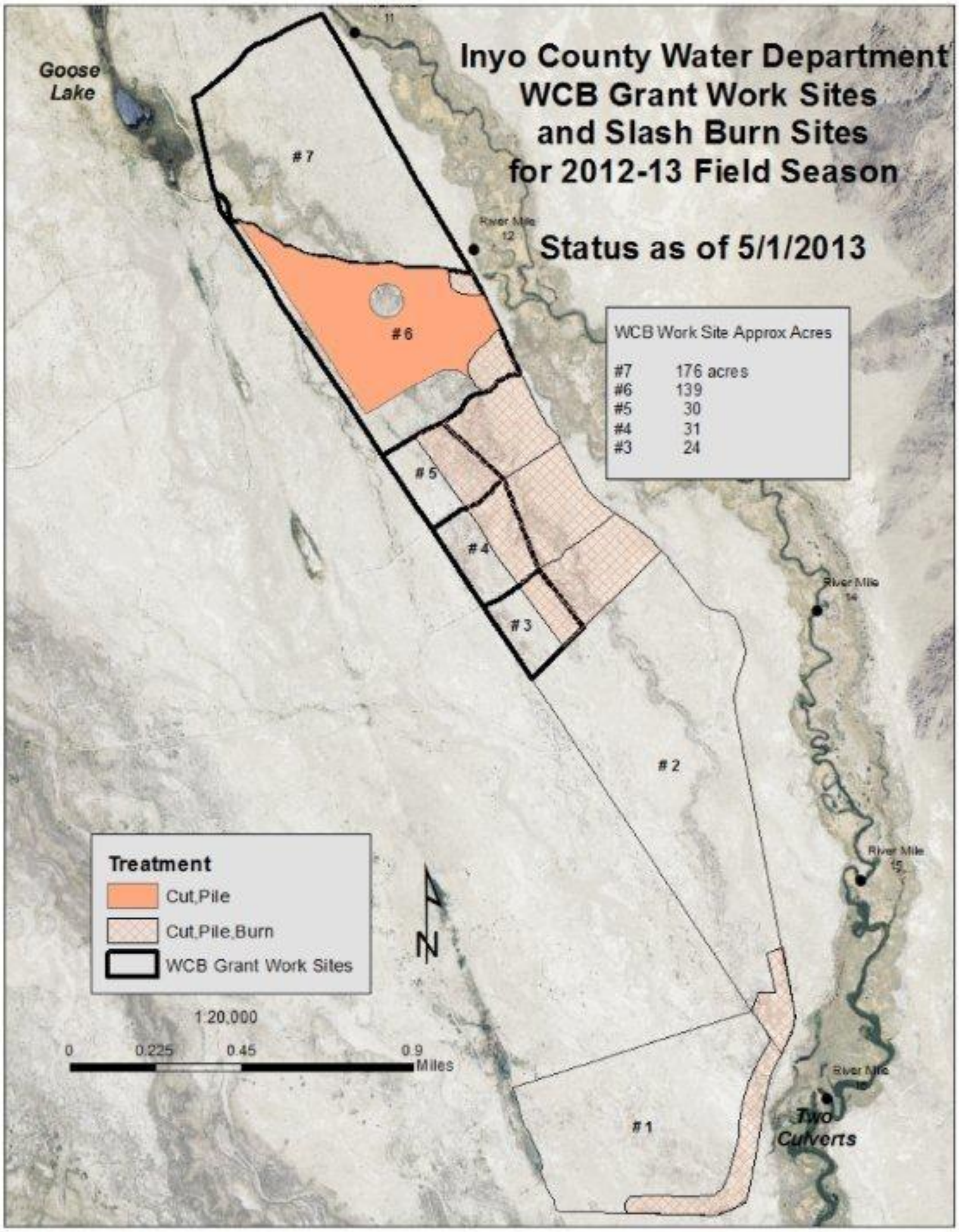


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Figure 5.1. Saltcedar areas treated during 2012-2013.

SECTION 6: MITIGATION PROJECTS STATUS

A central role of the Inyo County Water Department (ICWD) is to monitor and report on the status of environmental mitigation projects in the Owens Valley.

A central role of the Inyo County Water Department (ICWD) is to monitor and report on the status of environmental mitigation projects in the Owens Valley. More than 62 projects, spread throughout the Valley, mitigate for environmental impacts due to abandonment of irrigated agriculture and groundwater pumping in the Owens Valley. These projects range in size from 1-2 acre revegetation projects to the 78,000 acre Lower Owens River Project (LORP).

The majority of these projects are described in the Water Agreement and associated 1991 EIR (*Water from the Owens Valley to Supply the Second Los Angeles Aqueduct*), and in the 1997 MOU (*Resolving conflicts and concern over the 1991 EIR*). These governing documents are on the ICWD website. ICWD also participates in the development and implementation of new projects or existing projects that have been modified by the Inyo/LADWP Standing Committee or by court order.

This report provides background and status on mitigation projects that are yet to be implemented, or are underway, or have been completed in the Owen Valley. . This report pays specific attention to projects that ICWD believes are not implemented, not meeting management goals, or in need of plan revisions. The report is divided into three sections:

- Section A provides background information on the mitigation projects, including project origins and the impact for which mitigation is being provided.

- Section B provides a report on projects that are of greatest concern, or where the status of the project has changed during the reporting period.

- Section C is a table of all the projects described in the 1991 EIR and MOU. Information found here includes the project origin, impact being addressed, management prescription, development stage, and status.

Mitigation Projects Origins and Background

Descriptions of mitigation projects are found in the collection of documents that govern the activities of the LADWP in the Owens Valley. These are the 1991 Long Term Agreement and EIR, the 1997 MOU, and other court Stipulations and Orders. As these documents were developed over time, LADWP has committed to implement numerous projects to enhance recreation, land use, and the environment, or to mitigate for impacts in the Owens Valley.

All of the projects mitigate for impacts after 1970 that resulted from the operation of the second Los Angeles Aqueduct. The environment of the Owens Valley will never be as rich, or diverse, as it was in 1913. The Water Agreement requires that LADWP to avoid future environmental damage and implement mitigation and enhancement projects that to a certain degree will repair, restore and compensate for adverse impacts from the operation of the second aqueduct.

Most of the mitigation projects include goals to improve vegetation in the Owens Valley. More than 58,000 acres of groundwater dependent vegetation is in the Owens Valley. Between 1970 and 1990, increased groundwater pumping, and the resulting fluctuations in groundwater table, had a significant adverse effect on more than 1,000 acres. Of this, 655 acres of groundwater dependent vegetation completely died-off.

Mitigation alternatives

With respect to mitigation, the Water Agreement generally follows the framework of the California Environmental Quality Act (CEQA), which allows several alternative forms of mitigation. These are generally considered in sequence (i.e., with preference given to avoidance first and compensation last). These actions include:

- **Avoiding the impact altogether by not taking a certain action or parts of an action.**

  Local example: Well on/off provisions. When soil water and projected contribution from precipitation is inadequate to maintain vegetation, wells are not operated.

- **Minimizing impact by limiting the degree or magnitude of the action and its implementation.**

  Local example: Shutting down pumping wells, as was done at Five Bridges when groundwater drawdown degraded nearby vegetation.

- **Rectifying the impact by repairing, rehabilitating, or restoring the impacted environment.**

  Local example: Revegetation and regreening projects, which compensate for abandoned agriculture and reduce blowing dust and dirt.

- **Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.**

  Local example: Salt cedar control, ongoing irrigation of fields

- **Compensating for the impact by replacing or providing substitute resources or environments.**

  Local example: Lower Owens River Project, civic projects, recreational facilities, habitat enhancement projects, and fish hatcheries

Origin of Mitigation Measures

Mitigation planning, development, and implementation are ongoing activities that are undertaken cooperatively with LADWP; however, the majority of mitigation projects in the Owens Valley were developed by the two parties during three discrete periods of time in response to real or potential legal and administrative actions:

Environmental Projects (EP), 1970-1984

Between 1970 and 1984, LADWP committed about 10,000 acre-feet of water annually to implement several environmental projects. The primary purpose of these projects was to restore habitat that had been negatively affected or lost due to water gathering. These areas may have exhibited vegetation changes, or reduction in wildlife using a particular habitat. The goal was to provide a regular water supply to habitats, such as ponds, lakes, sloughs, springs, and the Lower Owens River (LOR). Objectives differed between the projects, depending on the type of the impact that had occurred, but the overall goal of the environmental projects was to improve wildlife, forage, fisheries, and public recreation facilities.

In many instances it was impractical to mitigate at the original impact site, or the affected area was not well defined, or sporadic. In these cases a project was constructed at a site that would best accommodate the goals of the mitigation.

- **Farmer's Ponds**: Water is provided each fall to offer increased habitat for migrating waterfowl; two miles north of Bishop.

- **Buckley Ponds:** Water is provided for a warm-water fishery and waterfowl area; three miles southeast of Bishop.

- **Saunders Pond:** Water is provided to a warm-water fishery and waterfowl area, five miles southeast of Bishop.

- **Millpond:** Water is provided to a pond at a recreation area either by creek flow or a well at the site.

- **Klondike Lake:** Water is provided for permanent wildlife habitat area now incorporated in Klondike Lake E/M Project.

- **Tule Elk Field:** Water is provided to irrigate a pasture heavily used in summer by tule elk; between U.S. Highway 395 and Tinemaha Reservoir.

- **Seely Spring:** Maintained by an LADWP well adjacent to Owens River to provide waterfowl and shorebird habitat larger than had existed at Seeley Spring; two miles south of Tinemaha Reservoir.

- **Calvert Slough:** Water is provided to maintain habitat; small pond and marsh area near LADWP Aqueduct Intake.

- **Little Blackrock Spring:** Water is diverted from ditch to maintain wetland area at original spring site.

- **Lone Pine Pond:** Water is provided by natural seep or spring flow in river with supplemental releases from Alabama Gates (now incorporated in lower Owens River E/M Project); north of Lone Pine Station.

- **Lower Owens River:** Water releases began in 1975 to provide year-long minimal flows in lower Owens River, as well as releases to Twin Lakes, Billy Lake, and Thibaut Ponds; to maintain waterfowl, marsh, shorebird, and upland gamebird habitat, as well as a warm-water fishery. The project has now been replaced by the LORP.

- **Diaz Lake:** A supplemental water supply is provided to Diaz Lake recreational area. The accounting of water supplied to this project has been revised as part of the MOU 1600 ac-ft. projects described below.

Enhancement/Mitigation Projects, 1984-1991

The Enhancement/Mitigation (E/M) projects are environmental projects that were implemented prior to adoption of the 1991 EIR. The Water Agreement required that all E/M project continue and some of these projects were included in the 1991 EIR as mitigation for impacts due to LADWP's water gathering activities. The amount of water allocated to these projects, along with the water used is reported in Table 6.1.

Public meeting in communities throughout the valley provided the background on which Enhancement/Mitigation (E/M) projects were established. E/M projects addressed a number of environmental impacts and community needs included revegetation of abandoned agricultural lands or revegetation of lands that experienced vegetation loss due to groundwater pumping, regreening of public parks, improving wildlife habitat, and partial rewatering of the lower Owens River. For each project, specific goals and objectives were established and environmental documentation was prepared in accordance with CEQA.

- **Millpond Recreation Area Project:** Located west of Bishop, was the first E/M measure to be completed. Since October 1985, funds have been provided to operate the recreation area's sprinkler irrigation system that waters 18 acres of the community park including two softball fields.

- **Shepherd Creek Alfalfa Lands Project:** Revegetation of 198 acres of abandoned cropland adjacent to U.S. Highway 395 with sprinkler-irrigated alfalfa and windbreak trees. The property between Lone Pine and Independence had only sparse annual vegetation since 1976, and was a source of blowing dust creating a traffic hazard.

- **Klondike Lake Project:** Previously, the 160-acre lake located north of Big Pine had been filled only during above-normal runoff years. Now, less than 1,700 af of water maintains the lake year-round. Benefits include nesting and feeding areas for waterfowl, and recreation including skiing, windsurfing, and other water sports in summer months. Due to the shape and size of the Klondike lakebed, the full volume of water (2,200 af) allocated to the project was more than the lake required, so the project was modified to permanently reduce the water allotment. The balance of this unused water allocation was apportioned the Big Pine Ditch System and the Klondike South Shore Habitat Area.
- **Laws Historical Museum Project:** Provides a regular water supply to improve the native vegetation on a 21-acre parcel, establish irrigated pasture on 15 acres, and establish windbreak trees, all adjacent to the museum.

- **640 acres near Laws:** Revegetating with non-groundwater dependent native plants (potential project that would require Standing Committee approval to implement).

- **Laws-Poleta Native Pasture Project:** Provides water for irrigation of 220 acres of sparsely vegetated land to reestablish native vegetation on abandoned pasturelands and increase livestock grazing capabilities.

- **McNally Ponds and Pasture Project:** To provide a regular water supply to existing ephemeral ponds (60 acres) in the Laws area to create a waterfowl habitat, and to provide spring and summer irrigation to enhance and maintain existing vegetation on 300 acres of pastureland. Provides water for 300 acres during the spring and summer months to irrigate pastureland and to 60 acres of ponds during the fall months for waterfowl habitat.

- **Independence Pasture Lands/and Spring Field Projects:** Revegetated approximately 910 acres of abandoned croplands and sparsely vegetated land to create native pasture lands and provide water to native vegetation. Involved conversion of sparsely vegetated land east of Independence to productive native pasture land by flood irrigation. The project mitigated a source of blowing dust and stabilized soil previously affected by severe wind erosion.

- **Lone Pine Riparian Park:** To provide a continuous water supply to a ditch running through Russell Spainhower Park then easterly to supply water to Lone Pine Woodlot and Richards and Van Norman Fields projects.

- **Van Norman (160 acres) and Richards Fields (160 acres):** Provides surface and pumped water to establish pastureland and increase livestock grazing capabilities on abandoned agricultural land.

- **Lone Pine Sports Complex:** At the request of the community, portions of the Lo-Inyo Elementary School and vacant LADWP property were converted to an outdoor sports complex consisting of baseball fields, soccer fields, and related parking, picnic and park areas.

- **Independence and Lone Pine Woodlots:** Two irrigated projects in Lone Pine and Independence provide a greenbelt and are harvested as sustainable source of firewood for the needy.

- **Independence Roadside Rest:** This project consisted of planting shade and windbreak trees and grass, installation of an irrigation system, and placement of picnic tables on a 1/2-acre site south of the town of Independence. The project is an aesthetic improvement over the previously blighted area.

- **Eastern California Museum:** This project enhanced the appearance of the Eastern California Museum grounds in Independence. It consisted of a small pond, trees, expanded lawn areas, and installation of an irrigation system.
- **Town Regreening Projects:** Three projects designed to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the towns of Big Pine, Independence, and Lone Pine. Lone Pine has been implemented; Big Pine and Independence should come into operation in 2014.

- **Lower Owens River Rewatering E/M Project:** This project provided up to 18,000 AFY of continuous flow of water in the previously dry (1913-1986) portion of the river channel, creating a warm water fishery and wildlife habitat in the southern Owens Valley. The project also supplies water to five small lakes along the river route providing improved waterfowl habitat in the region. This project has been superseded by the Lower Owens River Project.

- **Hines Springs:** Create 1-2 acres of aquatic, riparian, and marshland habitats. Project will serve as a restoration research project.

Table 6.1. E/M water allocation and water supplied 2004-2012

Project	Normal Year Water Supply (EIR)	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	9-Year Average *Supplied*	9-Year *Total*	9-Year EIR Total
McNallyLaws/Poleta Native Pasture Lands	660	1,682	1,269	1,241	1,396	1,320	1,764	1,267	2,306	1,460	**1,523**	**12,023**	**5,280**
McNally Ponds	4,000	0	1,522	1,491	0	0	0	368	857	0	**471**	**4,238**	**32,000**
Laws Historical Museum	150	32	59	99	147	63	131	152	105	138	**103**	**926**	**1,200**
Klondike Lake[1]	1,700	1,278	1,203	314	1,201	1,195	1,169	1,195	1,086	1,144	**1,087**	**9,785**	**13,600**
Lower Owens River Rewatering	18,000	8,910	7,566	5,904	0	0	0	0	0	0	**7,460**	**22,380**	**54,000**
Independence Pasture Lands	2,350	2,489	3,330	2,785	3,272	2,588	1,962	2,397	2,545	2,324	**2,632**	**23,692**	**18,800**
Independence Springfield	1,500	280	519	1,850	1,962	1,554	1,530	1,356	1,136	1,188	**1,264**	**11,375**	**12,000**
Independence Ditch System	725	451	356	359	380	515	446	497	496	165	**407**	**3,665**	**5,800**
Independence Woodlot	120	276	190	226	237	335	220	569	175	334	**285**	**2,562**	**960**
Shepherd Creek Alfalfa Lands	990	1,072	1,152	1,206	1,100	1,183	1,166	1,212	1,073	1,019	**1,131**	**10,183**	**7,920**
Lone Pine Park/Richards Field	1,230	916	1,085	870	570	1,012	1,037	1,037	1,194	481	**911**	**8,202**	**9,840**
Lone Pine Woodlot	120	76	100	120	78	51	58	123	120	156	**98**	**882**	**960**
Lone Pine Van Norman Field	480	337	474	512	306	28	147	102	116	97	**235**	**2,119**	**3,840**
Lone Pine Regreening	95	238	180	107	232	228	283	257	298	223	**227**	**2,046**	**760**
Total	**32,120**	**18,327**	**19,356**	**17,429**	**11,186**	**10,646**	**10,695**	**10,807**	**11,847**	**8,914**	**13,245**	**119,207**	**256,960**

Additional Mitigation Projects, 1997 MOU and 2004 Amended Stipulation and Order

- **Yellow-Billed Cuckoo (YBC) Enhancement Mitigation Project:** These projects located near Big Pine on Baker Creek and Hogback Creek near Lone Pine were designed to enhance vegetation conditions and direct land management actions to enlarge and enhance existing YBC habitat.

- **1600 acre-feet of water:** Commits 1600 acre-feet of water at seven sites. The initial project recommended by the MOU consultant was replaced by seven projects prepared by an Ad Hoc group of Inyo, LADWP, and CFG staff, local lessees, and representatives of the Owens Valley Committee and the Sierra Club. A report describing the projects is on the ICWD website.

Current Project Status

This section describes the current status of projects implemented as part of the Water Agreement. Particular attention is given to large projects that are underway or recently implemented. The ICWD also has raised concerns whether certain projects are meeting their specified goals. Projects discussed in detail include: the Lower Owens River Project, MOU Additional Mitigation Projects, revegetation projects, Klondike Lake South Shore Waterfowl Habitat Area, and the regreening projects in Independence and Big Pine.

Lower Owens River Project (LORP)

Environmental monitoring of the LORP is continuing to provide information used by scientists and project managers to evaluate project conditions and make adjustments to management when required. We have found that by many measures the LORP is a success, but in this 5th year of monitoring it is still too early to state that the goals of the LORP are on track to being fully met.

As in previous years, LORP monitoring activities were carried out in all management units (River-Riparian System, Blackrock Waterfowl Management Area, Off-River Lakes and Ponds, and the Delta Habitat Area). Work on the LORP in fiscal year 2012-13 conducted by LADWP and Inyo County included:

- Maintenance activity such as cleaning sediment accumulations and obstructions from water measurement facilities, ditch maintenance, fence repairs, and adjustments to flow control structures

- Hydrologic monitoring and analysis of river baseflows and seasonal habitat flows, the ponded area of the Blackrock Waterfowl Management Area (BWMA), the level of the Off-River Lakes and Ponds, and baseflows, pulse flows, and seasonal habitat flows to the Owens River Delta.

- Development of a river flow model of the Lower Owen River was completed by Northwest Hydraulics. Their report is available from the ICWD website

- Biological and water quality monitoring included water temperature and dissolved oxygen monitoring, rapid assessment survey (RAS), avian census, wetted area measurement, and range monitoring. Not all monitoring tasks are conducted every year. A list of monitoring by year can be found in the LORP Adaptive Management and Reporting Plan, which can be found on the ICWD website: http://www.inyowater.org/LORP/DOCUMENTS/LORP_MonitoringAdaptiveManagmentPlan_042808.pdf. (note: this 41 MB document may require considerable time to download)

- Rangeland monitoring included irrigated pasture condition scoring and utilization trends. Woody species recruitment monitoring was added in September 2010 in order to assess potential livestock influences on regeneration of desirable woody species

- Other work included saltcedar control, weed abatement, and mosquito control

Complete observations from the 2011-12 field season are in the 2012 LORP Annual Report, which can be found on the ICWD website (www.inyowater.org).

Summary of 2012 LORP Observations

By some measures the LORP appears on track, but other observations are not reassuring. The most striking observation from the river-riparian area is the continued encroachment of tules. Tules are an expected and natural feature in the LORP ecosystem. However, they are now so prevalent that they are influencing the developing riparian environment to the extent they may become a limiting factor in ecosystem development and an impediment to recreation and ranching.

Tules can have a significant impact on the project:

- Tules narrow the river and increase water velocity in the constricted channel resulting in down cutting

- Riverbanks occupied by tules essentially prevent river borne willow and cottonwood seed from reaching soils best suited for their germination

- Tules block recreational boating and fishing access for much of the river

- Tules displace pasture used by cattle

The goal of developing a Lower Owen River riparian canopy suitable for supporting woodland habitat indicator species remains elusive. Recruitment of tree willow in the riparian area is occurring, but very slowly and in limited areas. Most seedlings were found near an existing mature seed source despite seasonal habitat flows in 2010 and 2011 that were more than the maximum prescribed flow rate of 200 cfs and released near the peak of the willow seed drop. Almost no recruitment of cottonwood is occurring in the LORP.

During the RAS (a survey at the water's edge of the river and other components of the LORP), seedlings or juveniles of tree willows were found at 69 sites along the river and in the Delta Habitat Area. Of these, only 14 sites had more than 5 seedlings present. No cottonwood seedlings or juveniles were discovered anywhere in the LORP in the 2012 survey, and only a few recruits have been discovered over the life of the project.

Seedlings found in one year were revisited the next to judge survivorship. Seventy-two percent of seedlings found during the 2011 RAS were relocated in 2012. This is similar to the 75% survival documented in 2011.

LORP Recreational Use Plan (RUP)

It is anticipated that the LORP will become a popular recreation area that will appeal to those who enjoy hiking, biking, bird watching, wildlife viewing, hunting and fishing and other outdoor activities. Increasing visitor use is expected each year for the first 10-15 years of the project.

Developing a RUP will provide a mechanism to comprehensively identify resource-appropriate recreational opportunities and evaluate these in relation to: environmental and habitat objectives of the LORP; maintenance of warm water fishery, LADWP operations, cultural resources, cattle grazing and other agricultural activities. The LORP RUP will address community concerns that cultural resources and working landscapes be protected; and feasibility, cost of implementation and maintenance of new programs, facilities, and uses.

The development of the RUP consists of preparing three options selecting a recommended option to present to the public, and finally presenting a final plan to Inyo County and LADWP for their approval. The draft RUP was released to public in February 2012, and final preferred plan was presented to the Inyo County Board of Supervisors, and the Inyo/Los Angeles Standing Committee in February 2013. Both bodies recommended the plan proceed to a final design stage with environmental review.

MOU Additional Mitigation Projects (AMP)

The 1997 MOU commits LADWP to implement additional mitigation that will provide a total 1,600 acre-feet of water per year to mitigate for impacts at five springs in the Owens Valley that have lost some or all of their flow. On-site mitigation measures were developed at Hines Spring and the balance of the water was allocated other projects in the Owens Valley. The document, Additional *Mitigation Projects Developed by the MOU Ad Hoc Group* can be found at www.inyowater.org.

On-site mitigation at Hines Springs was discussed in the 1991 EIR, 1997 MOU and in the 2004 and 2005 Stipulation and Order (documents can be found at www.inyowater.org) as mitigation for impacts at Fish Springs, and at Blackrock and Seely Springs. The Hines Springs project, which was implemented in March 2012, consists of two components: provides 385 acre-feet annually of surface and pumped water to create ponded water or tule marsh, and provide water for cattle. At Freeman Creek, water is being diverted back into ancestral washes to support a riparian corridor and pasture. At a site north of Mazourka Canyon Road, a new flowing well augments supply from an older well to create spring and seep habitat and provide stock water. Four miles southeast of Independence, the Homestead project relies on a new flowing well to create a short flowing channel with riparian vegetation and a one acre pond. The Well 368 project includes a new artesian well to augment water for an existing Owens Valley Pupfish refuge. In addition, to these biological projects, Diaz Lake will be supplied a secure amount of water, which reduces the amount of water pumped by Inyo County to supply the lake. Warren Lake, north of Big Pine will receive the annual balance of water not used in the above projects to enhance shorebird and wildlife habitat.

Annual water commitments are as follows: Freeman Creek (215 af), Hines Spring Well 355 (240 af), Hines Spring Aberdeen Ditch, (145 af), North of Mazourka Canyon Road (300 af), Homestead (300 af), Well 368 (150 af), Diaz Lake (up to 250 af), and Warren Lake (receives the balance of 1600 af).

Yellow-Billed Cuckoo Habitat Enhancement Project

Implementation of a project to enhance and maintain Yellow-Billed Cuckoo habitat was initiated in the spring of 2009. The project site was fenced and planting of cottonwood and willow began in the spring of 2010.

On March 18-19, 2011, the Center Fire began at the western edge of the Baker Creek, which, fanned by 70 mile-per-hour wind, destroyed the bulk of the forest canopy deemed most suited for the cuckoo. There are indications that the area will naturally recover. Three months after the fire, new growth had sprouted from charred willow stumps. It is unknown how long it will take the habitat to return to a condition that will support breeding cuckoos, however the Hogback Creek site experienced a catastrophic fire in 1998, and by 2009 had reestablished a dense tree canopy.

Black Locust removal is continuing, and new poles are being prepared for planting in 2013 to replace plantings that failed to thrive.

Revegetation projects identified in the 91 EIR and Irrigation in the Laws Area MND (Table 6.2)

Revegetation projects mitigate for environmental damages due to groundwater pumping and/or discontinuation of agriculture. A mitigation plan for these projects dates back to August 1999 (http://www.inyowater.org).

It is frequently quoted that active revegetation is a slow process, which may require a decade or more to achieve, but despite well over a decade of research and considerable experimentation, the majority of revegetation projects in the Owens Valley are not showing obvious signs of improvement.

LADWP reported that only four of sixteen revegetation parcels have met required cover and composition goals. None of the abandoned agricultural revegetation projects are close to meeting their goals. To date, the only revegetation efforts to have succeeded were those that came back on their own once the water table was allowed to recover; no intervention, except fencing and the elimination of grazing, was needed.

The majority of the revegetation projects require some form of irrigation to support transplanted stock. However, most of these projects were not supplied adequate irrigation and as a result have not achieved revegetation goals. Members of the public, Inyo County Water Commission, the ICWD, and other agencies have voiced concern about the lack of progress, especially in the Laws area, where after nine years little revegetation has occurred and blowing dust from these parcel continues to impact nearby residents.

Table 6.2: Status of Revegetation Projects:

Guiding Document	Project name	Acres	Impact[3]	Met goal?	% Live Native Cover		# Species	
					Goal	Reported	Goal	Reported
91 EIR/97 MOU	LAWS 118	107	ABAG	NO	11.5%	2% [4]	11	No report
91 EIR/97 MOU	BISHOP 97	124	ABAG	NO	15.0%	4.8% [4]	12	No report
91 EIR/97 MOU	FIVE BRIDGES	300	GP	NO	60.0%	47.0%/74.0% (2 sites)	4	5/6 (2 sites)
91 EIR/97 MOU	BIG PINE 160	211	ABAG	NO	17.7%	3% [4]	10	No report
91 EIR/97 MOU	TINEMAHA 54	0.4	GP	NO	33.0%	2.14% [4]	3	No report
91 EIR/97 MOU	BLACKROCK 16E	7.5	GP	YES	34.0%	37.0%	6	14
91 EIR/97 MOU	HINES SOUTH[2]	11.5	GP	NO	33.0%	–	TBD	–
91 EIR/97 MOU	INDEPENDENCE 105	42	GP	YES	25.0%	>25.0%	4	>4
91 EIR/97 MOU	INDEPENDENCE 123	42	GP	YES	17.0%	>17.0%	4	>4
91 EIR/97 MOU	INDEPENDENCE 131 N	23	GP	YES	17.0%	16.2% [4]	4	5
91 EIR/97 MOU	INDEPENDENCE 131 S	50	GP	NO	17.0%	6.15% [4]	4	No report
ILA*	LAWS 90	94	ABAG	NO	10.0%	No survey	10	No survey
ILA	LAWS 94	47	ABAG	NO	10.0%	No survey	10	No survey
ILA	LAWS 95	44	ABAG	NO	10.0%	No survey	10	No survey
ILA	LAWS 118/129	50	ABAG	NO	10.0%	No survey	8	No survey
ILA	LAWS 27 (SEED FARM)	118	ABAG	NO	10.0%	No survey	8	No survey

YES (green)	Met Goals - Project Complete
YES (yellow)	Determined by LADWP to have met goals in 2012
NO (red)	Not meeting goals

*ILA, Irrigation in the Laws Area MND

[1] 32 acres removed for irrigation

[2] An acreage figure has not been established

[3] Abandoned agriculture, lands removed from agriculture (ABAG); increased groundwater pumping (GP)

[4] Surveyed August 2012

Revegetation Mitigation Projects Described in the 1991 EIR

The 1991 EIR identified mitigation for lands that were made barren due to increased groundwater pumping, or the abandonment of agriculture. The 1997 MOU, which supplements the 1991 EIR, describes the goals for the revegetation projects:

> *The content of the mitigation plans will be in accordance with the EIR, which provides that on-site mitigation will be accomplished through revegetation with native Owens Valley species and through establishment of irrigation. The mitigation plans may include schedules for conducting research and testing revegetation techniques.*
>
> *As reliable methods are developed for large-scale revegetation applicable to the different characteristics of the affected areas, the initial revegetation goals contained in the EIR, or in the initial plan, for each site will be refined or modified as necessary. In refining or modifying the revegetation goals for the affected areas, a preference will be given to revegetation that will restore the area to vegetation conditions similar to those that previously existed. If this cannot be feasibly and reliably accomplished because of the characteristics of the area, or for other reasons, the next preference will be to establish perennial vegetation comparable to that in nearby areas. If this is not feasible, revegetation with other native Owens Valley species will be the preferred goal.*

Beginning in 1991, studies and test plots were used to examine various methods that could be used to effectively and efficiently revegetate arid lands. Based on these studies and experiments, revegetation plans called for in the 1997 MOU and Long-Term Water Agreement (LTWA) were released in August 1999. The plans are titled, *Revegetation Plan for Impacts Identified in the LADWP, Inyo County EIR for Groundwater Management* and can be found on the ICWD website.

All the revegetation projects were fenced in 1999 to eliminate disturbances. Experimental techniques were tried at plots within some sites to test various methods of revegetation with the goal of developing techniques that could be applied to all projects. Sites were prioritized according to the difficulty of the project and threat of continued degradation. At sites where natural recruitment was taking place, passive techniques--simply fencing the land--was all that was called for. At the most disturbed sites where top-soil had eroded, it was established through studies that systematic irrigation would be required to cultivate native perennial transplants.

LADWP reports the following work was accomplished in 2012 on the 1991 EIR revegetation projects, as well as plans for the projects in 2013 and beyond:

- Laws 118: in 2011 18 acres were drill seeded. In 2012 a buried drip irrigation line was installed, and a new fence was constructed. The site was found to have 2% cover when surveyed in 2012, so the parcel is not meeting cover goals. LADWP reports that they will likely not plant this parcel until after 2015, which is after they have completed planting Laws parcels 90, 94, 95, and 129.

  The Irrigation in the Laws MND (2003) specifies that 32 acres of parcel 118 is to be flood irrigated to create and maintain native pasture; however this section has not been irrigated. LADWP is working with the lessee to get water onto the land.

- Bishop 97: approximately 35 acres were drill seeded in 2011, and a buried drip system was installed on approximately 16 acres. This parcel has 4.8% native perennial cover. The goal for this project is 15% cover.
- Five Bridges: Water was release from C Drain three times during the growing season. Water spread was assessed visually. Permanent transects and photo points were monitored, and weed control continued. LADWP is not following the approved mitigation plan for Five Bridges, which requires flood irrigation from high flows from the Owens River. A revised plan for this project had been circulated, but has not been approved by the Technical Group. Under LADWP's management plan, the percent of native perennial cover and composition of that cover, as measure by LADWP, varies quite a bit from year to year, but generally the cover has been in decline during this seven year period, which was recorded in LADWP's annual report.
- Big Pine 160: About 20 acres were drill seeded in 2011. LADWP is still evaluating a water source and designing an irrigation supply. Transects conducted in August 2012 found 3% native perennial cover.
- Laws 118: LADWP reports that in 2013 a drip irrigation system was installed that covers much of the parcel.
- Tinemaha 54: No work has been reported by LADWP. This parcel is not meeting cover and composition goals. A 2012 survey found 2.14% cover.
- Blackrock 16E: The site has attained cover and composition goals, and no work was reported.
- Hines South: This project has not been implemented. Planning was to begin after the Hines Spring projects were completed in March 2012. Although the Hines Springs projects were implemented by deadline they are not fully performing as designed due to the character of the soils at the site. A decision was made to delay planning for three years in order to allow an assessment of the Hines Spring project.
- Independence 105 and Independence 123: It is reported that these sites have attained cover and composition goals.
- Independence 131N: This parcel was surveyed in the summer of 2012 and transects show that vegetation cover was 16.2%, which is just below the required 17% vegetation cover goal; however, the revegetation plan allows that when cover is 90% of the stated goal it is considered rehabilitated.
- Independence 131S: approximately 21 acres were drill seeded. LADWP reported in 2011 that buried drip irrigation was to be installed in 2012, but no progress report has been received.

The 1999 mitigation plan for these revegetation projects provides that, "After seven years, these overall goals should be reexamined to assess whether they are realistic or need revision. Assessment will include the level of effort expended on the project and a statistical evaluation of the status of the cover and composition of desirable and weedy species". It has been 13 years and no reevaluation has taken place.

Irrigation in the Laws Area MND (ILA), Revegetation Projects (233 acres)

These revegetation projects are the result of the reclassification of some of the formerly irrigated land in the Laws area. In the 1990's the Laws Ranch agricultural fields were supplied irrigation water for pasture and alfalfa until a dispute between the lessee and LADWP ended with the lessee abandoning the farm. Without water, topsoil from the fallow ground became a source of blowing dust. The Laws Ranch became a dust source in the area.

In order for the Laws Ranch to be efficiently irrigated, Inyo County and LADWP agreed to redesignate these formally irrigated parcels from Type E (lands supplied with water) to Type A (vegetation that can survive on available precipitation). In trade, certain parcels in the Laws area were reclassified Type E, so that an equivalent acreage remained irrigated.

Three parcels in the Laws area that were previously irrigated farmland will be revegetated: Laws 90 (101 acres), Laws 95 (46 acres), and Laws 129 (47 acres). Another two Laws parcels, which are mapped as abandoned agricultural land, Laws 94 (40 acres) and a portion of Laws 118 (18 acres) surrounding Laws 129 will also be revegetated.

The mitigation plan for the Irrigation Project in the Laws Area, MND, entitled, *Revegetation Plan for Lands Removed from Irrigation Laws Parcels 90, 95, and 129 and Abandoned Agricultural Land Parcel 94* was released in 2003 (www.inyowater.org). The plan describes restoring native perennial cover that closely approximates the vegetative cover and species composition of nearby parcels with similar ecological site descriptions. All parcels are to irrigated until the project is complete. The project will be considered complete when, after two years of having discontinued irrigation and other activities, the prescribed cover and composition is maintained. The plan provides specific goals for total vegetative cover, species composition, and a project schedule; which is to establish at least a 10% cover of native perennial vegetation composed of 10 native perennial species in Laws 90, 94, 95, and 8 native perennial species in Laws 129/118 by 2013. LADWP believes parcel 129/118 will achieve these goals by 2013.

LADWP reports that the planting on all of the Laws parcels will be complete by 2014-15, but has not provided a revised plan and schedule that describes when project goals are expect to be met. The Plan for the Irrigation Project in the Laws Area requires that beginning in 2010, if revegetation is not on schedule, the annual report is to be expanded. The Water Department has asked LADWP to provide the expanded report and a new timeline.

Although LADWP is years behind schedule, they are making a concerted effort to accelerate work on these projects. They have refined their greenhouse propagation techniques and are placing thousands of deep-rooted transplants at buried drip emitters in the project parcels. LADWP has built a second greenhouse doubling the number of plants they can grow for revegetation projects. New drip irrigation systems are being installed, or expanded to allow for additional plantings. LADWP has employed a water master to oversee irrigation, which is crucial; many of earlier plantings were lost when irrigation systems failed, or were not supplied with water.

While progress on these projects is evident, the Water Department still has concerns that these projects will not meet the Plan’s cover and composition goals. Plants, including perennial grasses, are being placed at water emitters on a grid with 10 foot grid spacing. Even if all transplants survived (as of 2011, it appeared that less than 60% survived), and each individual plant attained a full canopy, plants placed with such a large spacing would be unlikely to attain a 10% cover. LADWP suggests that cover will expand with new recruitment, but there is no evidence that natural recruitment is occurring in the Laws parcels. As well, LADWP is not monitoring survivorship, and has not committed to replacing transplants that have died.

Another concern is competition for resources by weedy species, primarily tumbleweed (*Salsola tragus*), which covers much of the land in these parcels. Weeds are taking advantage of moist soils at the drip emitters and competing with transplants. Under the mitigation plan, Salsola is not a species LADWP is required to treat, but without management, many of the new transplants will be needlessly lost.

We hope to work with LADWP, to revise the Plan for the Irrigation Project in the Laws Area, to assist with monitoring, and assure that these projects will ultimately succeed. The revised Plan will be submitted to the Technical Group for review and approval. The Irrigation Project in the Laws Area, MND will be amended with the revised plan.

Two parcels identified from mitigation in the Irrigation in the Laws Area MND, totaling 162 acres, have not been implemented. The 32 acre portion of Laws 118 that is to be converted to irrigated pasture has not received water, and Laws 50, which is to be flood irrigated, has not received water. The Laws 50 parcel has been the subject of complaints from The Great Basin Unified Air Pollution Control District to LADWP.

Five Bridges

In 1988, approximately 300 acre of vegetation in the Five Bridges area, located about 3.5 miles north of Bishop, were observed to have died off or were in decline. The impact was attributed to local groundwater pumping and the effects of drought. A mitigation plan for the site was developed in 2002, but it was never approved by the Technical Group. The mitigation goals are to restore the area to a complex of vegetation communities with similar species composition and cover as existed prior to impact. The goal will be attained when alkali meadows have live cover of 60% that is composed of four perennial species and riparian areas attain live cover of 90% composed of four perennial species. In the unadopted plan, these goals were to be attained at the end of the 2007 growing season. Five Bridges is presently managed using controlled burns, grazing restrictions, weed control, and water spreading.

LADWP's Annual Owens Valley Report provides transect results from two alkali meadow sites beginning in 2004 (Table 6.3). Since 2004, species composition goals have been met; however, vegetation cover in these same areas has varied greatly over time. Of interest is survey data that show a general decline in meadow vegetation cover at the two reported permanent transect sites. Transect L4 had met, or nearly met, required cover only during the first four years in which project data had been reported (LADWP's Owens Valley report, years 2004-2011), and although cover has increased in the past two years, it has not rebounded to early levels. Transect L5 has generally met 60% cover goals, but like L4, cover has trending downward. LADWP's annual reports noted the decline, and LADWP staff believes that peaks likely corresponded with high river flows and dips to off-site water management. They point out the general increase in vegetation since cover was first measured; in 1989 cover at L4 was 3.9% and L5 was 15.9%.

Table 6.3. Species Cover and Composition at Five Bridges, recorded by LADWP 2003-2011 (red text indicates measured values below project goals).

Year	2004	2005	2006	2007	2008	2009	2010	2011
L4 Transect %Cover	59	61	68	61	52	47	39	47
L4 Transect Composition	5	4	4	4	5	5	5	5
L5 Transect %Cover	78	89	93	70	74	43	61	74
L5 Transect Composition	6	7	7	7	6	7	6	6

Klondike Lake, South Shore Waterfowl Habitat Area (SSHA)

Klondike South Shore Habitat Area is to be provided 200 acre-feet of water per year for the purpose of creating and maintaining an open-water habitat for waterfowl and a shallow-flooded habitat for shorebirds.

LADWP had encountered problems conveying the assigned volume of water between Klondike Lake and the adjoining SSHA. There is very little gradient between the two projects, and as a result, less than half the water allocation could be supplied in most years. Water releases to the project area were:

2007 – 96 af
2008 – 89 af
2009 – 80 af
2010 – 92 af
2011 – 200 af
2012 – 200 af

In 2011 a new gate was opened between the lake and habitat area, and water delivered to the site was reported to be 200 af in 2011 and 2012. New habitat was created with the additional water, and areas of open water have developed and are being used by shorebirds and waterfowl.

Encroachment by emergent vegetation into the project area is a concern. Tules have largely filled in the open water habitat that had formed when the original gate provided the majority of water. A program to reduce the tules and restore habitat will need to be designed and implemented once the newly wetted habitat has established.

Independence Eastside Regreening Project and Big Pine NE Regreening Project

Independence Eastside Regreening

This project, which mitigates for impacts due to groundwater pumping and surface water diversions, consists of constructing a new water supply well in the town of Independence and irrigating approximately 30 acres immediately north of Market St. and east of Clay St.

From 2002 to 2008, the project underwent several rounds of review and reconsideration by Inyo County. In April 2009, the Standing Committee revised the scope of the project to allow sprinkler irrigation, to relocate the well to reduce noise at neighboring residences, and to allow for an onsite stable and corral. The Technical Group has evaluated and approved the new well at the site, CEQA has been completed on the project and LADWP has drilled the well, and selected a lessee. The irrigation system will be installed in late 2013 or early 2014, and irrigation will begin in 2014.

Big Pine Northeast Regreening (30 acres)

The Inyo County/ LADWP Technical Group approved an amended mitigation plan in the spring of 2010. The Big Pine Canal was identified as a source of project water. Replacement water up to 150 AFY will be supplied by Well 375. The effect of pumping Well 375 to supply this project has been modeled and water drawdown is predicted to be negligible. The Water Department modeled the effects of pumping Well 375 during the irrigation season for ten years. The model took into consideration pumping effects at three locations and if Well 375 was pumped at 150 AFY the water table at these sites was predicted to decline less than 0.2 feet.

The new project scope allows for sprinkler irrigation or flood irrigation. The original project description anticipated flood irrigation. It is estimated that sprinklers would reduce the project's water use from 150 AFY to 90 AFY.

LADWP had completed a mitigated negative declaration in November 2011 and began work to identify a lessee and build project infrastructure, but in April 2012 the Owens Valley Committee, Sierra Club, and Big Pine Paiute Tribe sued LADWP on the grounds that an EIR was required. In November 2012 the court ruled that LADWP's original CEQA document, the 1991 EIR, described the project and was adequate for the project to proceed. LADWP reports that they have identified a lessee and will construct the irrigation system after the 2013 irrigation season and irrigation will begin in 2014.

Mitigation Table (projects arranged north to south)

This table contains detailed information for each mitigation project, including the current status, origin, project description, and the impact it mitigates.

The *Origin* column lists the project starting point and any subsequent consideration of the project over time. Many of the Enhancement Mitigation projects (E/M), which were implemented prior to the 1991 EIR were continued. Some projects identified as Environmental Projects (EP) that were implemented prior to 1985, were identified as mitigation in the EIR. The Impact Number, if provided, is from Section 7 of the 1991 EIR, and associates the mitigation measure with the pre-project setting and type of environmental; it also describes the significance of the environmental impact. Non-E/M projects were largely developed in response to an impact that occurred subsequent to the EIR. Some non-E/M projects provide substitute mitigation, or mitigation not specific to an impact identified in the 1991 EIR.

The *Impact* column summarizes the environmental impact being mitigated. The *Prescription* column describes the activities and goals from the associated mitigation plan or other agreement. The project's state of development, relative to the project's goals, is reported in the *Development Stage* column. The Status column summarizes recent project activity.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Laws/Poleta Native Pasture (southeast of Laws) (216 acres)	E/M 1985-1990[1] 1991 Owens Valley EIR Impact No. 10-16	The Laws area has lost all or part of its vegetation cover due to increased groundwater pumping, abandonment of irrigated agriculture to supply water to the second aqueduct, livestock grazing and drought.	Annually provide water to approx. 216 acres in two locations to enhance and maintain existing vegetation and increase livestock grazing capacities while continuing the activity that caused the impact. (First implemented 1988).	Implemented and ongoing.	One pasture is adjacent to and east of Hwy. 6 (160 acres, parcel 44). Only the eastern half of the pasture has been effectively irrigated. The ICWD will investigate why the native pasture SE of Laws (60 acres, parcel 138) does not appear to be fully irrigated, although cover is high, it is patchy, with grasses mainly limited to ditches. LADWP had reported that they cannot separate this project's water accounting from adjacent irrigated parcels. Projects were supplied a combined 1,460 acre-feet in 2012-13.
McNally Ponds and Native Pasture	E/M 1985-1990 1991 Owens Valley EIR	The Laws area has lost all or part of its vegetation cover due to increased groundwater pumping,	Create waterfowl habitat by annually filling ponds Sept-Jan. Enhance and maintain vegetation and	Implemented and ongoing This project and Laws	In the past, the Inyo Board of Supervisors has approved water reductions due to drought conditions. LADWP

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
(348 acres)	Impact No. 10-18	abandonment of irrigated agriculture to supply water to the second aqueduct, livestock grazing, and drought.	increase livestock grazing capacities by irrigating 100 acres of native vegetation and ~200 acres of native pasture. (First implemented 1986-1987).	Poleta Native Pasture were supplied no water in 2012-13	currently describes the water supply to the ponds as provided only when water is diverted from the Owens River to the McNally canals. The adjacent 100-acre pasture has low patchy grass cover. Pastures on the east side of the river (200 acres) maintain grass cover. During the 2012-13 runoff year, neither the ponds or pasture received any water.
640 acre potential revegetation near Laws	E/M 1985-1990 1991 EIR Impact No. 10-18	The Laws area has lost all or part of its vegetation cover due to increased groundwater pumping, abandonment of irrigated agriculture to supply water to the second aqueduct, livestock grazing and drought.	Standing Committee to consider revegetating with non-groundwater dependent native plants and continuing the activity that caused impact.	In progress	The Standing Committee has not evaluated the need for mitigation of this area. Desert Aggregates expanded gravel mine operation includes at least 174 acres in the western part this potential mitigation site.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Five Bridges area revegetation (300 acres)	1991 Owens Valley EIR Impact No. 10-12	Between 1987 and 1988, two wells in the Five Bridges area that were pumped to supply water to enhancement mitigation projects contributed to a lowering of the water table under riparian and meadow areas along Owens River. Approximately 300 acres of vegetation were affected, and within this area, approximately 36 acres lost all vegetation due to a wildfire. EIR v1 (10-58)	Manage pumping to restore water table levels, supply surface water, and restore meadow and riparian vegetation through active revegetation efforts. Inyo and LA are responsible for plan development and implementation.	In progress	Water has been spread over the affected area since 1988. By the summer of 1990, revegetation of native species had begun on approximately 80 percent of the affected area. LADWP and Inyo County are developing a plan to revegetate the entire affected area with riparian and meadow vegetation. This plan will be implemented when it has been completed. Several activities have taken place in the Five Bridges area, but the Technical Group has not approved management changes to the mitigation plan. Providing surface water to the site has increased cover in some areas. The area north of the river that was originally in

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					the impact area appears to have declined in cover and requires attention but his area was not addressed in the mitigation plan. In March 2005, LADWP informed the Water Department that limited grazing in some enclosures had resumed. The Technical Group needs to agree on a revised mitigation plan for the Five Bridges area.
Farmers Pond	EP 1970-1984 1991 EIR Impact No. 10-18	The Laws area has lost all or part of its vegetation cover due to increased groundwater pumping, abandonment of irrigated agriculture to supply water to the second aqueduct, livestock grazing and drought.	Water provided in fall of each year to offer increased habitat for migrating waterfowl; two miles north of Bishop.	Implemented and ongoing	Implemented and ongoing

Project	**Mitigation Origin**	**Impact**	**Prescription**	**Development Stage**	**Status**
Revegetation near Laws (160 acres)	Non-E/M Project 1991 EIR Impact No. 10-18	The Laws area has lost all or part of its vegetation cover due to increased groundwater pumping, abandonment of irrigated agriculture to supply water to the second aqueduct, livestock grazing and drought. EIR v1 (10-66)	Native plant revegetation. Mitigated Negative Declaration (MND) allows approx. 32 acres to be converted to flood irrigated pasture.	Incomplete	The Technical Group implemented a 10-acre study plot in 2001 in lieu of initiating the planting of container plants as required in the Mitigation Plan. The mitigation project area has decreased in size due to the Laws Irrigation MND.
Laws Museum Pastures (21acres and 15 acres)	E/M 1985-1990 1991 EIR Impact No. 10-18	Significant adverse vegetation decrease and change have occurred in the Laws area due to a combination of factors, including abandoned agriculture, groundwater pumping, water spreading in wet years, livestock grazing, and drought.	Enhance the museum grounds by irrigating pastures east and west of the museum. This project was revised in the Laws reirrigation MND.	Implemented and ongoing	Both museum pastures had a cover of weedy species in the past. Condition of project and irrigation system will be monitored. LADWP reports that the project was supplied 138 acre-feet of water in 2012-13
Laws area	1991 EIR Impact No.	Significant adverse vegetation decreases and changes have	Monitor and reduce groundwater pumping where suspected impacts	Incomplete	County and LADWP are in disagreement over the need to operate the McNally

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
	10-18	occurred in the Laws area due to a combination of factors, including abandoned agriculture, groundwater pumping, water spreading in wet years, livestock grazing, and drought.	have occurred. Mitigate according to the Agreement, if necessary.		canals to avoid impacts to vegetation. Monitoring of select vegetation parcels is ongoing.
Millpond Recreation Area	EP 1970-1984; E/M 1985-1990	Non-specific compensation.	Pay for costs of running well to provide water to pond and thus create wet habitat.	Implemented and ongoing	Implemented and ongoing.
Buckley Ponds	EP 1970-1984 1991 EIR Impact No. 11-1	Non-specific compensation.	Provide habitat for warm-water fishery and waterfowl by maintaining a year-round pond.	Implemented and ongoing	Implemented and ongoing.
Bishop Area Revegetation Project. (Bishop 97)	Non-E/M Project 1991 EIR Impact No.	Non-specific compensation.	Revegetate with non-groundwater dependent native vegetation.	In progress	In progress, but behind schedule. LADWP estimates that successful revegetation could take a decade or longer. Fencing to eliminate

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
(120 acres)	10-16				disturbance has been installed. The Mitigation Plan (MP) provided that test plots would be implemented if the area did not demonstrate vegetation recovery. Vegetation cover was re-sampled in 2003 to compare with 1999 baseline cover. Results showed little to no change. Another survey is planned for 2012. The MP provides that revegetation efforts would be expanded in 2009, five years after implementation of test plots. In 2011-12 drip irrigation was expanded and about 2,180 containerized plants were planted. The parcel was surveyed in 2012 and found to have attained a 4.8% native perennial cover.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Saunders Pond	EP 1970-1984	Non-specific compensation.	Provide wet habitat by maintaining operation of year-round pond.	Implemented and ongoing	Implemented and ongoing.
Klondike Lake	EP 1970-1984; E/M 1985-1990 1991 EIR Impact No. 11-1	Non-specific compensation.	Improve waterfowl habitat and provide recreation in the Big Pine area. The Big Pine Ditch MND (2004) reduced the water supply to 1,700 acre-feet, provided maintenance of native pasture and wetland habitats adjacent to Lyman ditch, and committed LADWP to maintain a described a lake level. Up to 200 acre-feet/year would be used for a native habitat area. (First implemented 1987).	In progress .	Motorized recreation on the lake has been limited to prevent the introduction of the freshwater quagga mussel LADWP reports runoff year 2012-13 water use was 1,144 acre-feet.
Klondike South Shore Waterfowl Management Area (160 acres)	1991 EIR Impact No. 11-1 Addition to	Compensation for the inability to supply water to the Klondike Lake Project.	When initiated, the Klondike Lake Project was expected to use 2,200 AF, but the project consumes less than 1,500 AF. South	In progress	The elevation between the Lake and the Project is minimal and sediment in the water conveyance limited flow to the project. A new

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
	Klondike Lake project 2005		Shore project was initiated to create waterfowl habitat just south of the lake with water that could not be delivered to Klondike Lake. Two hundred AF was allocated for this purpose.		water gate was installed and in 2011-12, and 2012-13, a full 200 af allocation was supplied. New habitat has been created and is being used by desired species. It has been the practice of LADWP to release water to the project area during waterfowl migration season, usually beginning releases in late winter, but as of April 2013 water had not been supplied to the project.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Big Pine Northeast Regreening (30 acres)	E/M 1985-1990 1991 EIR Impact No. 10-19	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Manage pumping in accordance with the Agreement and establish irrigated crop.	In progress	The Inyo County/ LADWP Technical Group approved an amended mitigation plan in the spring of 2010. Modifications include a change in water source. The Big Pine Canal will serve as a source of project water. Replacement water, (equal to or less than 150 AFY) will be supplied by Well 375. The new project scope allows sprinkler irrigation as well as flood irrigation. It is estimated that sprinklers will reduce the project's water use from 150 AFY to 90 AFY. In April 2012, a lawsuit seeking to declare the ND inadequate and asking that a full EIR be developed was presented. The Court found that the CEQA document and the case dismissed in 2013.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					Implementation of the project is scheduled for the 2014-15 runoff year.
Big Pine Ditch System	Non-E/M Project 1991 EIR Impact No. 10-19	Non-specific compensation.	Establish/restore ditch system through Big Pine.	Implemented and ongoing	This project was completed in the summer of 2010, and provides water to 85% of Big Pine residents.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Big Pine Revegetation (20 acres)	E/M 1985-1990 1991 EIR Impact No. 10-19	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	This is an undefined potential enhancement/mitigation (E/M) project that will become a native plant site if permanent irrigation is infeasible Establish an irrigated crop while continuing the activity that caused the impact.	Incomplete and ongoing	Portion of parcel 160 to west of BP Canal. LADWP reports "The site was fenced in 2007 to eliminate disturbances and encourage natural revegetation. If this area does not revegetate naturally, it will be included with LADWP's ongoing revegetation efforts."
Revegetation near Big Pine (160 acres)	Non-E/M Project	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Revegetate with non-groundwater dependent native species while continuing the activity that caused the impact.	Incomplete and ongoing	LADWP reports, "The site has been fenced. Permanent transects were run in 2006. In the spring of 2011 approximately 20 acres were drill seeded with locally collected seed." Transects run in August 2012 show 3% native perennial cover
Steward Ranch	Non-E/M Project	Compensation for loss of well.	Compensation agreement with ranch owner.	Implemented and ongoing	Mitigation agreement is in place.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
	1991 Owens Valley EIR Impact No. 9-14				
Big Pine general	Non-E/M Project	Non-specific compensation.	Valley-wide mitigation by Agreement management provisions.	Inactive	Implemented.
Fish Springs Hatchery	EP 1970-1984; Non-E/M Project 1991 Owens Valley EIR Impact No. 10-14	CDFG fish hatchery and the LORP serve as compensatory mitigation.	No on-site mitigation will be implemented at Fish Springs, however, the CDFG fish hatcheries at these locations serve as mitigation of a compensatory nature by producing fish that are stocked throughout Inyo County.	Implemented and Ongoing	Implemented
Tule Elk Field	EP 1970-1984	Non-specific compensation.	Provide water in summer to field used by tule elk between U.S. Highway 395 and Tinemaha Reservoir.	Implemented and ongoing	The water supply to this project has been reduced since 2002. ICWD does not agree the project allocation is sufficient in all years to

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					meet project goals.
Big and Little Seely	EP 1970-1984 1991 Owens Valley EIR Impact No. 10-14	Non-specific compensation.	Maintained by LADWP well adjacent to Owens River to provide year-round waterfowl and shorebird habitat larger than had existed at Seeley Spring Two miles south of Tinemaha Reservoir LADWP well number 349, discharges water into a pond approximately one acre in size. This pond provides a temporary resting place for waterfowl and shorebirds when the pumps are operating or Big Seely Spring is flowing. Riparian vegetation has become established around this pond. (eir v1, 10-62)	Implemented and ongoing	Implemented and ongoing.
Calvert Slough	EP 1970-1984	Non-specific	Water provided to maintain habitat for a	Inactive	This project has not been receiving a regular water

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
		compensation.	small pond and marsh area near LADWP Aqueduct Intake.		supply since 1998. LADWP reported that low flows in the creek do not allow supplying the project because of high ditch losses and the off status of the two wells upstream of the project. No water was supplied to this project for seven years (1998-2004).
Hines Spring	E/M 1985-1990; 1997 MOU; 204 and 2010 Stipulation and order. 1991 EIR Impact No. 10-11	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland vegetation is lost.	The Hines Spring vent and its surroundings will receive on-site mitigation. Water will be supplied to the area from an existing, but unused, LADWP well at the site. As a result, approximately one to two acres will either have ponded water or riparian vegetation. Hines Spring will serve as a research project on how to re-establish a damaged aquatic habitat and	In progress	The initial concept, to provide water at the spring vent, proved impractical. MOU Parties entered into an ad hoc process and agreed to build two projects at the spring site; 1) water from Well 355 now supplies water to a small pond used by livestock. The solar power source designed to power Well 355 would be insufficient, so the project was modified to include a new above-ground power

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
			surrounding marshland. Riparian trees and a selection of riparian herbaceous species will be planted on the banks. The area will be fenced. (EIR) v.1 10-62)		line to the project; 2) Aberdeen Ditch. A 2700' pipeline now supplies water to a ditch just to southeast of the former spring that will be used by livestock.
Taboose/Hines Spring – Blackrock Areas Revegetation Project (80 acres)	Non-E/M Project 1991 EIR Impact No. 10-11	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland vegetation is lost.	Manage pumping and revegetate with native species. These lands will not be permanently irrigated, but will be revegetated with native Owens Valley vegetation not requiring irrigation except during initial establishment.	In progress	This mitigation measure consists of 3 sites that total approx. 115 acres. Hines Spring. A mitigation plan and schedule for will be developed by March 8, 2015; 3 years after the Hines Spring mitigation project had been completed. Tin 54 (0.3 acres) 108 alkali sacaton plants were planted in 1999. A drip irrigation system has been utilized. Blk 16E 7.2 acres. LADWP reports that based on 2010 transects the project has

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					attained the cover and composition goals in the revegetation plan. The cover goal is 35%
Little Blackrock Springs	EP 1970-1984 1991 EIR Impact No. 10-14	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland vegetation is lost.	LADWP will continue to supply water from Division Creek to the site of the former pond at Little Blackrock Springs, to maintain marsh vegetation at this site will thus be maintained.	Implemented and ongoing	An operations plan is needed. LADWP had reported that the Goodale Bypass Ditch that supplies the project normally runs all year at less than 1 cfs, providing approx. 700 acre feet a year.
Big Blackrock Springs	Non-E/M Project 1991 EIR Impact No. 10-14	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland vegetation is lost.	No on-site mitigation will be implemented at Big Blackrock Springs; however, the CDFG fish hatcheries at these locations serve as mitigation of a compensatory nature by producing fish that are stocked throughout Inyo County.	Implemented and ongoing ICWD calculates runoff year 2009-10 water use was 13,354 acre-feet	The fish hatchery is in place.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Thibaut/Sawmill marsh habitat	Non-E/M Project 1991 EIR Impact No. 10-20	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland vegetation is lost.	The Blackrock Waterfowl component of the LORP will provide compensatory and some on-site mitigation. Vegetation impacts will be mitigated under the Agreement.	Implemented and ongoing	Implemented under the LORP.
Independence Pasture Lands (610 acres)	E/M 1985-1990 1991 EIR Impact No. 12-1	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Develop and irrigate pasture or alfalfa fields (first implemented 1987-1988).	Implemented and ongoing	Site topography prevents flood irrigation from reaching some portions of the project. LADWP reports runoff year 2012-13 water use was 2,324 af.
Billy Lake	EP 1970-1984 1991 EIR Impact No. 11-1	Non-specific compensation.	Maintain wet habitat to provide waterfowl habitat in the region.	Implemented and ongoing	Operations plan is needed.
Independence East Side	E/M 1985-1990	Regreening projects implemented to enhance	Manage pumping and establish irrigated crop.	In Progress	The Technical Group evaluated and approved a

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Regreening (30 acres)	1991 EIR Impact No. 12-1	the aesthetics of abandoned agricultural or pasture lands in areas around the towns of Big Pine, Independence, and Lone Pine. Water is supplied from LADWP to promote and maintain vegetation.			new well at the site, and CEQA was completed. LADWP has drilled the new well and put out a request for proposals to identify a lessee. The project should be fully implemented in 2014.
Independence Woodlot (21 acres)	E/M 1985-1990 1991 EIR Impact No. 10-13	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Create irrigated crop.	Implemented and ongoing	Lone Pine FFA is been managing the project, with some wood going to Independence residents with the majority being sold in Lone Pine to support FFA activities. An operations plan is needed based on management guidelines agreed to by Inyo Co. and LADWP. The project was supplied

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					334 af water during 2012-13.
Independence Springfield (283 acres)	E/M 1985-1990 1991 EIR Impact No. 12-1	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Manage pumping and establish native pasture or alfalfa (first implemented 1988).	Implemented and ongoing	40 acres were identified as still requiring mitigation. Water supply during runoff year 2012-13 was 1,188 acre-feet.
Additional regreening w/in Independence Springfield (40 acres)	E/M 1985-1990 1991 EIR Impact No. 12-1	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Revegetate with native pasture.	Not Implemented	This project is overdue. LADWP reports that planting will be initiated in the 2012-2013 runoff year.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Symmes/Shepherd wellfield revegetation (60 acres)	Non-E/M Project 1991 EIR Impact No. 10-13	Increased groundwater pumping from wells in the Symmes-Shepherd area has caused a substantial reduction of vegetation cover in approximately 60 acres in three areas immediately to the east of the pumping wells. The affected vegetation was previously supplied by shallow groundwater and surface seeps. EIR v1 (10-59)	A revegetation program will be implemented for these effected areas utilizing native vegetation of the type that that has died off. Water may be spread as necessary in these areas to accomplish the revegetation. EIR v1 (10-59)		Two of the four sites included in this mitigation measure is behind schedule. The 3 sites total approx. 115.2 acres. Ind 123 (28.4 acres) did not have test plots implemented in 2002 as scheduled in the Mitigation Plan. LADWP in 2011 reports that goals have been attained. Ind 131, north and south. (73.2 acres). The Technical Group implemented revegetation test plots in Dec. 2001. A final report from the consultant was received in Nov. 2003. LADWP's consultant conducted additional revegetation studies, and reports on methods and results from this effort have not been made available. The schedule in the

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					Mitigation Plan called for expanding revegetation efforts for Ind 123 and 131 in 2007. LADWP reports in 2011 that the north plot is not attaining goals. Transects will be run in 2012. The south plot was drilled with native seed in 2011. Transects will be run in 2012. Ind 105 (13.6 acres) cover data increased from 1999 to 2001, thus no active revegetation activities are planned. The initial cover of 8.1% increased to 13.5%. The goal for the site is 17% perennial native cover. The site has attained prescribed cover and composition goals.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
Shepherd Creek Alfalfa Field (200 Acre)	E/M 1985-1990 1991 EIR Impact No. 12-1	Dust mitigation	Manage pumping and establish irrigated crop on approx (first implemented 1986).	Implemented and ongoing	Alfalfa planted and maintained on approx. 185 acres. LADWP reports that water supply for runoff year 2012-13 was 1,019 af.
Expand Shepherd Creek Alfalfa (60 acres)	E/M 1985-1990 1991 EIR Impact No. 12-1	Dust mitigation	Expand E/M project to east of Hwy 395 if vegetation cover in that area remains sparse.		The Technical Group does not have mitigation or monitoring plans for this mitigation measure. LADWP has conducted vegetation transects and concluded that vegetation cover has increased from baseline and thus the mitigation is not necessary.
Reinhackle Spring	Non-E/M Project 1991 EIR Impact No. 16-11	Increased groundwater pumping has periodically reduced the flow from Reinhackle Spring. This spring is the source of water for a large pasture area and supports many	Manage groundwater pumping to avoid reductions in flow, and monitor and maintain vegetation to avoid significant change or decrease as provided in	Under investigation	A 2004 study concluded that the water flowing from Reinhackle Spring is similar in composition to aqueduct water and not similar to the deep aquifer samples or up-

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
		large tree willows. EIR v1 (10-61)	the Agreement and the Green Book.		gradient shallow aquifer wells. Testing to monitor the effect of pumping conducted May 2010 to April 2011. Data from these tests are being analyzed. A draft management plan is under consideration by the Technical Group.
Lone Pine Ponds	EP 1970-1984; E/M 1985-1990 1991 EIR Impact No. 11-1	Non-specific compensation.	Wildlife enhancement. Similar to Buckley Ponds and Saunders Pond; water provided by natural seep or spring flow in river with supplemental releases from Alabama Gates (now incorporated in lower Owens River E/M Project); north of Lone Pine Station.	Implemented and ongoing	This project will be included as part of the off-river lakes and ponds in the LORP.
Lone Pine East Side Regreening (11 acres)	E/M 1985-1990 1991 EIR Impact No.	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas	Create irrigated pasture.	Implemented and ongoing	LADWP did not report water use for this project in runoff year 2012-13.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
	10-16	around the town. Water is supplied from LADWP to promote and maintain vegetation.			
Lone Pine Woodlot (12 acres)	E/M 1985-1990 1991 EIR Impact No. 10-16	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Revegetate and provide irrigation.	Implemented and ongoing	Lone Pine FFA irrigates the woodlot and distributes wood according to plan developed by the Technical Group LADWP reports water use was 156 af for runoff year 2012-13.
Richards Field (189 acres)	E/M 1985-1990 1991 EIR Impact No. 10-16	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Create irrigated pasture or alfalfa field (first implemented 1987).	Implemented and ongoing	This project had been modified without Standing Committee approval. During the non-irrigation season, water normally flows to the project after flowing through Lone Pine Riparian Park. LADWP informed the Water Dept. that the project will no longer receive water during the non-irrigation

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					season. Water to this project is not measured separately from the park supply. LADWP reports water use for Richards Field and Lone Pine Park was 481 af for runoff year 2012-13.
Van Norman Field (160 acres)	E/M 1985-1990 1991 EIR Impact No. 10-16	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Create irrigated pasture or alfalfa field.	Implemented and ongoing	LADWP reports water use was 97 acre-feet for runoff year 2012-13. The project is allocated 480 afy, but because of the parcel's irregular topography, and the sanding in of the on-site well, the project has not been supplied its full water allocation. A replacement well was drilled in the fall of 2012 and should begin production in late 2013. The new well is located in an position that should allow the

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					establishment of additional acres of pasture. As part of an E/M evaluation, Inyo County and LADWP are working to expand the project to include irrigating an adjacent 10 acre parcel operated as a school farm by Lone Pine High School. CEQA will be completed on the revised project in the summer of 2013.
Lone Pine West Side Regreening (7 acres)	E/M 1985-1990 1991 EIR Impact No. 10-16	Regreening project implemented to enhance the aesthetics of abandoned agricultural or pasture lands in areas around the town. Water is supplied from LADWP to promote and maintain vegetation.	Create irrigated pasture.	Implemented and ongoing LADWP reports water use was 257 acre-feet for runoff year	Implemented and ongoing LADWP reports water use was 223 af for runoff year 2012-13.

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
				2010-11	
Diaz Lake	EP 1970-1984	Non-specific compensation.	Provide supplemental water to recreation area and create wet habitat.	Implemented and ongoing	Under the Additional Mitigation project description, Diaz Lake will be supplied a secure source of water, which reduces dependence on water pumped by Inyo County up to 250 afy. LADWP's lease with Inyo County (Lease No. 1494, in effect until June 30, 2015) has been updated to reflect these additional water supply commitments and accounting requirements of this project agreed to by LADWP.
Lower Owens Rewatering Project	E/M 1985-1990 1991 EIR Impact No.	The Lower Owens Rewatering Project was initiated in 1986 by the LADWP and Inyo County to improve habitat for	Re-water the Owens River to create wet habitat for wildlife. Project includes off-river lakes and ponds. Under the project, 18,000	Replaced LADWP reports water use was 0 acre-feet for	The Lower Owens River Project incorporates this project

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
	10-14	shorebirds, waterfowl, and fish in the river corridor and at the Delta.. The project was one of 25 Enhancement/Mitigation Projects jointly implemented between 1985 and 1990.	acre-feet of water per year were to be released from the Blackrock Spillgate to maintain continuous flow in the Lower Owens River from the Blackrock area to the Owens River Delta. (first implemented, step 1, 1986).	runoff year 2010-11	
Lower Owens River Project	1991 DEIR; MOU 1997 1991 EIR Impact No. 10-14	The LORP is a in-kind compensatory mitigation for impacts related to LADWP's groundwater pumping that are difficult to quantify or mitigate directly such as the drying up of springs, seeps and loss of wetlands.	The Lower Owens River Project settles more than 24 years of litigation between the Department and Inyo County over groundwater pumping and water exports. The project is intended to mitigate for a host of lost environmental values in the reach of the Owens River from the Los Angeles Aqueduct Intake to Owens Lake, and associated springs and seeps and off-	Implemented and ongoing LADWP reports water use was approximately 17,020 acre-feet for runoff year 2010-11	Project implemented. In December 2006, LA began to release a 40 cfs flow down the river channel. Permanent base flows of 40 cfs were established on February, 20, 2007. In February 2008, Los Angeles initiated the first seasonal habitat flow. Adaptive management requires ongoing monitoring. Additional information about the LORP can be

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
			river lakes and ponds. 64 miles of the Owens River channel will be rewatered. The project includes the Delta Habitat Area, Off-river Lakes and Ponds, and a 1500 acre Blackrock Waterfowl Management Area		found at www.inyowater.org and in the 2011-12 ICWD Annual Report.
Meadow/riparian vegetation dependent on agricultural tailwater	1991 EIR Impact No. 10-14	Decrease in irrigated land resulted in reduction or withdrawal of tailwater and associated loss of dependant vegetation.	LORP serves as compensatory mitigation.	Replaced	LORP serves as compensatory mitigation.
Salt Cedar Control Program	1991 EIR Impact No. 10-6	Between 1970 and 1990, LADWP continued to spread surplus water in wet years in the spreading areas created by the dikes east of Independence between	Implement salt cedar control program in accordance with the Agreement.	Ongoing implemented	Approx. 23 mi. of the Owens River floodplain south of the aqueduct intake has been cleared of saltcedar. The program also monitors and maintains cleared areas. The current program is focused

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
		the aqueduct and the river. This activity increased soil moisture and water tables, but also fostered conditions favorable to the spread of salt cedar, which was established prior to 1970. (91 EIR)			on clearing saltcedar thickets in water spreading basin adjacent to the Lower Owens River.
Irrigated fields, including Cartago and Olancha	1991 EIR Impact No. 10-16	Decrease in irrigated land resulted in reduction or withdrawal of tailwater and associated loss of dependant vegetation.	Continue irrigation practices since 1981-82 and thereafter.		Ongoing. Irrigated lands are not directly monitored; instead, lessees are relied upon to indicate if there are changes in water for irrigation.
Fish Springs, Big and Little Seely, and Big and Little Blackrock	1991 EIR Impact No. 10-14	Ground water pumping has lowered depth to water to a level where springs and seeps no longer flow. Associated riparian and wetland vegetation is lost.	Monitor and maintain vegetation to avoid significant change or decrease as provided in the Agreement and the Green Book.		The Technical Group does not have a plan for monitoring flows or vegetation at springs and seeps. Ecosystem Sciences has completed a draft inventory of springs and seeps. According to the MOU, the inventory should

Project	Mitigation Origin	Impact	Prescription	Development Stage	Status
					provide baseline data adequate for monitoring change. ICWD provided extensive comments on the draft to Ecosystem Sciences.

[1] DEIR, V1 (p. 5-19)

[2] DEIR, V1 (p. 5-20)

[3] Last status report Oct 2008

SECTION 7: VEGETATION CONDITIONS

Abstract

A primary goal of the Long Term Water Agreement between Inyo County and Los Angeles Department of Water and Power is to manage groundwater and surface water while maintaining healthy groundwater-dependent vegetation communities found in the Owens Valley. Each year the Inyo County Water Department monitors selected vegetation parcels within the valley to ensure that these goals are met. This report addresses two main questions regarding vegetation conditions: (1) changes in cover and composition among groups of parcels with respect to the effects of groundwater management using control and wellfield parcels (2) changes in cover over time within particular vegetation parcels. In general, wellfield parcels have been below baseline measurements while control parcels have maintained baseline conditions or actually exhibit higher cover than baseline. The 2012 reinventory data show that several individual vegetation parcels are below their baseline measurements. For example, in the Laws wellfield, perennial cover is below baseline in 61% of parcels sampled in 2012. Valley-wide conditions indicate shrub cover is increasing in wellfield parcels as grass cover decreases. Individual parcels that do not exhibit changes in overall perennial cover may be experiencing a conversion in vegetation type from grass-dominance to shrub-dominance. In short, there have been measurable changes from baseline both this year and across time.

Introduction

A primary goal of the Long Term Water Agreement between Inyo County and Los Angeles Department of Water and Power is to manage groundwater and surface water while maintaining healthy groundwater-dependent vegetation communities found in the Owens Valley.

This report presents an analysis of the 2012 vegetation conditions measured by the Green Book Line Point Transect (hereafter LPT) Monitoring Program.

This report presents an analysis of the 2012 vegetation conditions measured by the Green Book Line Point Transect (hereafter LPT) Monitoring Program. Each year, the Inyo County Water Department monitors vegetation conditions on the floor of the Owens Valley. The primary goal of this monitoring, according to the Green Book are to detect any *"significant decreases and changes in Owens Valley vegetation from conditions documented in 1984 to 1987"*. Vegetation live cover and species composition documented during the 1984-87 mapping effort were adopted as the baseline for comparison with each annual reinventory according to the Long-Term Water Agreement (Agreement). The reference measurements collected within individual areas mapped with similar vegetation (parcels) are referred to as 'baseline'.

The Green Book details certain decreases and changes in vegetation community types that must be avoided under the Agreement. Baseline vegetation communities in which evapotranspiration exceeds precipitation were classified as groundwater-dependent communities and are referred to as Types B, C, and D. These phreatophytic communities are dependent on shallow groundwater to maintain plant populations, as precipitation alone is inadequate to meet the water demand of evaporation and transpiration (Sorensen *et al.* 1991, Steinwand *et al.* 2006). For these parcels, according to the Green Book, *"the goal is to manage groundwater pumping and surface water management practices so as to avoid* *causing significant decreases in live vegetation cover"* AND TO PREVENT A SIGNIFICANT AMOUNT OF VEGETATION FROM CHANGING TO A *"vegetation type that precedes it alphabetically (for example, Type D changing to either C, B, or A vegetation)."* The goal is therefore to manage the effect of pumping on the depth to groundwater to maintain baseline plant communities using knowledge of rooting depth for dominant species associated with each plant community.

To determine whether significant decreases and/or changes in vegetation have occurred, three criteria need to be met that are described in the Green Book: (1) measurability of vegetation change, (2) attributability of vegetation change to LADWP groundwater pumping or surface water management and (3) degree of significance defined by the magnitude, extent, duration and permanency of the change along with other factors including air quality, human health, impact to species of concern, etc. To avoid confusion, it is noteworthy to highlight that the standard dictionary definition of "measurability" is the degree to which something can be measured. Vegetation of course can be measured and thus the first criteria for determining significant decreases or changes in vegetation may seem to the reader unfamiliar with the Green Book, unnecessary. However, the Green Book assigns a different definition to the term "measurability"—defined in part as a change that is statistically significant. Thus the first criteria, measurability, can be used interchangeably with statistical significance in the context of the technical appendix (Green Book) to the Agreement. A main objective of the vegetation annual report is to evaluate the statistical significance (measurability) of vegetation change compared to baseline. The second criterion, evaluating whether a statistically significant change in vegetation is caused by water management (attributability), is beyond the scope of this report owing to the need for a comprehensive analysis on a case by case basis for each vegetation mapping unit (parcel). Another source of confusion may arise with the third criterion which is the "degree or significance" of environmental change. For this criterion to be met, statistical significance is necessary but not sufficient. As described above, there are several other factors in addition to statistical significance that must be demonstrated to evaluate the degree of significance for the third criterion. For an example of a comprehensive evaluation of all three criteria for an individual parcel, see the report "Analysis of Conditions in Vegetation Parcel Blackrock 94" (available at www.inyowater.org).

A large proportion of groundwater-dependent parcels were mapped during baseline as Type C alkali meadows (61%), and the Agreement seeks to prevent these meadows from changing to shrub-dominated communities (Type B), a state change that is associated with increased depth to groundwater. Alkali meadows are of special concern because a small persistent increase in depth to groundwater beyond the maximum rooting depth is incompatible with their continued persistence (Naumberg *et al.* 1996, Elmore *et al.* 2006). Because alkali meadow only comprises 0.1% of the vegetation community types in California and 80% of alkali meadow community is found in the Owens Valley (Davis *et al.* 1998), local management of this community type has a disproportionate effect on the long-term persistence of these ecosystems.

To evaluate vegetation change in the Owens Valley, data were analyzed at both the valley-wide scale and for individual parcels. We addressed two questions at the valley-wide scale to evaluate differences between parcels affected by groundwater pumping and those that are relatively unaffected by groundwater pumping during the period of maximum pumping rate (1987-1993). These questions were: (1) whether the mean cover of the groups designated as either wellfield or control exhibited a statistically significant change over time compared to baseline cover values; and (2) whether vegetation composition in wellfield or control groups has changed over time compared to baseline values. Since determination of significant impacts is made on a case by case basis at the individual parcel scale, two questions were addressed to evaluate vegetation change for each individual parcel: (1) whether change in perennial vegetation cover has occurred over the twenty-two year reinventory period compared to baseline, (2) whether the relative proportion of woody vegetation (hereafter shrub), gramminoid vegetation (hereafter grass) and non-gramminoid herbaceous vegetation (hereafter herb) has changed compared to baseline and, (3) whether there has been a trend over time in vegetation composition.

Methods

The Owens Valley is located in east-central California, entirely within Inyo County. The valley is bounded by the Sierra Nevada to the west and the White/Inyo Mountains to the east. Runoff from the Sierra Nevada maintains a shallow water table in the valley that historically supported phreatophytic vegetation communities including alkali meadow, Nevada saltbush and rabbitbrush meadows. Perennial grasses dominate the alkali meadow vegetation communities, while shrubs and grasses co-dominate mixed meadows (Manning, 1997).

From September 1984 to Nov 1987, LADWP inventoried and mapped vegetation on 2126 vegetation parcels (223,168 acres). Many of these parcels are nonphreatophytic plant communities or are distant from pumped areas. In the summer of 2012, ICWD resampled 110 parcels using the line point protocol described in the Greenbook (a complete list is contained in Appendix 1). Parcels were initially selected based on meeting one or more of the following criteria: (1) parcel contained a permanent monitoring site; (2) baseline data was collected for the parcel; (3) parcel was in close proximity to a pumping well; (4) information of past and current land use for parcel was available; (5) parcel was representative of one of the plant communities originally mapped during baseline; (5) soil characterization was available for the parcel; (6) characterization of the landscape position was available for the parcel (Manning 1994). The average size of these vegetation parcels in which sampling was conducted was 88.1 acres (range 13.5-565.2 acres) and the total acreage of all parcels combined was 9690.9 acres. Between 13 and 36 transects were sampled in each vegetation parcel. Transect start locations and bearing were randomized in ArcGIS 10.0 software (ESRI 1995-2011, Jabis 2010).

Criteria for control or wellfield groups

Parcels were classified as either control or wellfield based on criteria derived from groundwater drawdown during the period of maximum pumping rate that occurred between 1987 and 1993. Two water table estimation methods were used to provide numerical criteria for these parcel classifications: (1) ordinary kriging, a geostatistical approach that relies on the spatial correlation structure of the test well data for weighting in order to interpolate groundwater depth for an entire parcel, and (2) groundwater-flow modeling estimates of groundwater drawdown contours shown on the baseline maps (Danskin 1998, Agreement Exhibit A: Management Maps, Harrington and Howard 2000, Harrington 2003). Parcels were designated as either wellfield or control depending on whether drawdown estimates from both kriged test well data and groundwater modeling were above or below critical values. Parcels were assigned wellfield status if (1) kriged DTW estimates exceeded 1-m water-table drawdown and (2) they were located at sites corresponding to modeled drawdown contours greater than 10 ft. Parcels were assigned control status if (1) kriged DTW estimates were less than 1-m and (2) they were located at sites corresponding to modeled drawdown contours less than 10 ft. If the kriged DTW estimates were not reliable owing to inadequate test well coverage near vegetation parcels (Harrington 2003), then the groundwater-flow model estimate of the 10-ft drawdown contour was used as the sole criteria to designate parcels as either wellfield or control. An exception to the above criteria was applied to parcels associated with drawdown contours greater than 10-ft yet located near a surface water source (specifically, a canal, sewer pond, creek, river, or a ground water seepage source) that would mitigate potential drawdown—these parcels were classified as control. Some parcels assigned the wellfield designation currently have higher water tables than during 1987 to 1993, but they retain the wellfield designation because the potential for pumping-induced groundwater drawdown is present owing to their proximity to pumping wells.

Statistical Analyses

Changes in vegetation cover and composition from baseline were evaluated at the valley-wide scale via comparisons of parcel groups (wellfield vs. control) and for individual parcels using transect data over time.

All statistical analyses were performed using R Version 2.15.3 (R Core Team 2013). The following R packages were used: ‘plyr’ (Wickham 2011), ‘reshape’ (Wickham 2007), ‘multcomp’ (Hothorn et al. 2008), ‘nlme’ (Pinheiro *et al.* 2013), and ‘car’ (Fox and Weisberg 2011). Statistical significance was declared at the $\alpha = 0.05$ level. In reporting results, the term significant refers to statistical significance. In this report the finding of statistical significance does not imply that the measurable change is attributable to ground and surface water management nor does statistical significance imply that there is a “significant impact”, a finding that would require further evaluation of both attributability and the degree of significance. Because the degree of change is of utmost importance in this monitoring program, we report effect sizes and confidence intervals where possible rather than p-values alone.

Analysis Variables

At the transect level, the data for each transect during a particular year represent the counts of vegetation cover ‘hits’ from a 50-m line-point transect sampled every 0.5 m—thus 100 hits are possible per transect. Perennial cover was chosen for analysis because annual species are not dependent on ground water and thus irrelevant to evaluating vegetation change in relation to ground water management. Perennial cover is further partitioned by life form categories grass, herb, and shrub.

In order to analyze the changes in the composition of total perennial cover, the proportion of shrub, herb and grass cover in comparison to total perennial cover was calculated at the transect level. Transect data are summarized for each year using the arithmetic average, creating a history of cover over time for each parcel. Other measurements taken each year at the parcel level include depth to water (DTW) and cover based on a spectral mixture analysis (SMA) (Elmore 2001). DTW values were not available for 2012 during the writing of this report in spring 2013. SMA values were not available for 2011 and 2012 due to discontinuation of Landsat 7 data use in previous years. Both measurements will be added to an updated Appendix 2, when the data become available.

A change profile for each parcel in the continuous parcel data was computed as the change in mean perennial cover for each reinventory year from baseline perennial cover. Each parcel is classified by its Holland type and by its status as either wellfield or control.

Analysis Data Sets

The number of parcels sampled each year as well as the number of transects sampled per parcel has varied due to staffing and technology changes. Thus, some parcels have varying numbers of transects sampled across time. Other parcels have not been sampled continuously during the entire monitoring period. In 2012, 110 parcels were sampled. For determinations of change from baseline, several subsets of the entire data set were used as follows:

1. **Parcels missing baseline transect data** (*n* = 11): The set of parcels resampled in 2012 for which baseline transect data is unavailable.
2. **Full transect data** (*n* = 99): The set of parcels with transect data from both the current year (2012) and at least one associated transect conducted during the baseline monitoring period (1985-1987) (*n* = 99). These parcels were further identified as belonging to the control or wellfield parcel group.
    a. Wellfield (*n* = 63)
    b. Control (*n* = 36)
3. **Continuous parcel data** (*n* = 36): The subset of full transect data that was sampled in every year from 1992 to the present. The year 1992 was chosen for the continuous parcel data because the sample size was greater than the set of parcels sampled each year from 1991 to the present. The baseline year was assigned to the nominal value of 1986 for these data. These data were further identified as either control or wellfield and by alkali meadow.
    a. Wellfield (*n* = 24)
        i. Continuous transect data – alkali meadow wellfield (*n* = 15)
    b. Control (*n* = 12)
        i. Continuous transect data – alkali meadow control (*n* = 10)
4. **Regression data set** (n = 82): The subset of full transect data with at least 10 years of data including the nominal baseline year.
    a. Wellfield (*n* = 49)
    b. Control (*n* = 33)

Analysis of parcel groups: wellfield vs. control

MANOVA was used to assess whether there was a difference in level or shape of the change profile over time between wellfield and control parcels. This allowed a direct evaluation of the effects of parcel status (wellfield or control) and time (1992-2012) on changes from baseline. The change profile was defined as the difference between the mean annual cover for each year and baseline. To allow for arbitrary changes in variance from year to year, and also for arbitrary dependence between errors from year to year, a fully unstructured correlation matrix was used. To avoid confounding the evaluation of the effects of environmental conditions on cover with the effects of varying the sample size between years, analyses were performed on the continuous parcel data and on the alkali meadows subset of the continuous parcel data. Model fit was assessed using graphical analysis of residuals.

To assess directly whether there was a change from baseline across parcels in mean perennial cover or mean grass cover, a paired t-test was used. Tests were performed using the full parcel data. Wellfield and control parcels were analyzed separately.

Analysis of covariance (ANCOVA) was used to assess whether there were differences in the linear trend of total perennial, grass cover, herb cover and shrub cover wellfield and control parcels. This analysis was performed using the continuous parcel data. The grouping variable was parcel status (wellfield or control), and the continuous variable was cover regressed on time. Linear trends were subsequently estimated using simple linear regression. Model fit was assessed using graphical analysis of residuals.

Individual parcel analyses

To evaluate in which parcels and in which year(s) total perennial cover has significantly differed from baseline, analysis of variance (ANOVA) followed by Dunnett's method of multiple comparisons was used to evaluate significant changes compared to baseline for each year that the parcel was sampled. To automatically adjust for unequal variance in the measurements taken across time, a weighted ANOVA was performed, using weights that were the reciprocals of the variance at each year. Dunnett's method controls the overall Type I error (finding a significant effect when there is none) when multiple comparisons are employed (Zar 1999). This method could only be used for parcels in which baseline data contained more than one transect. The results from the weighted ANOVA and Dunnett's multiple comparisons were grouped into three categories: significantly below baseline, no difference from baseline, and significantly above baseline. These data were displayed on maps of the parcel data.

To assess whether composition has changed within each vegetation parcel, a regression of shrub proportion (shrub cover/total perennial cover), grass proportion, and herb proportion over time was performed for all parcels in the full transect data with at least 10 years of vegetation data (including baseline) (regression data set, n = 82 total, n = 33 control, n = 49 wellfield.

Results

Analysis of parcel groups: wellfield vs. control

Comparison of change profiles between wellfield and control groups–MANOVA results

Figure 7.1 displays the change profiles for wellfield and control parcels that were continuously sampled, as well as for the alkali meadows subset of these parcels. Figure 7.2 breaks out the overall cover by each lifeform category.

The change from baseline of mean perennial cover of wellfield parcels (n = 24) differed significantly from the change from baseline of mean perennial cover of control parcels (n = 12) (n = 21 yrs (1992-2012), p = 0.0058, Figure 7.1a). Inter-annual trends or the shape of the change profile in the two groups have been similar during the reinventory period and thus evidently the level of the difference between the change profiles drives these results. Specifically, cover in the control parcel group was higher than or close to baseline while cover in the wellfield parcel group was generally lower than or close to baseline. For the alkali meadow parcel group sampled each year during this same time period (1992-2012), the general pattern and level of difference were similar; however, the comparison between wellfield (n = 17) and control (n = 10) parcels was not significant (n = 21 yrs, p = 0.211, Figure 7. 1b).

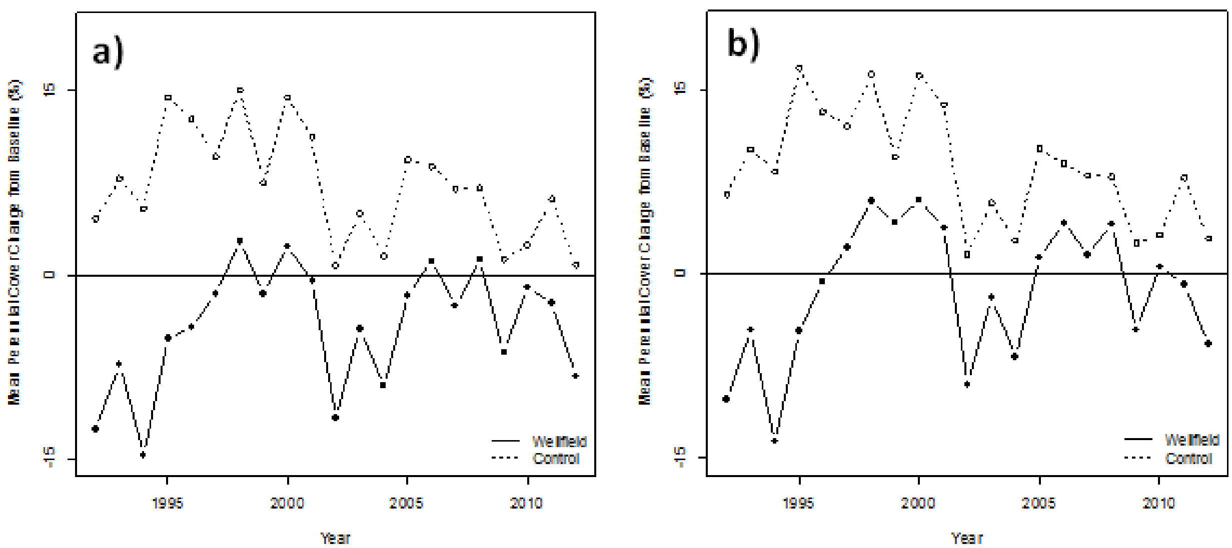

Figure 7.1. The mean change from baseline of mean perennial cover for the parcels sampled each year between 1992 and 2012. (a) For all parcels with continuous samples (n=36). (b) For alkali meadow parcels with continuous samples (n = 25).

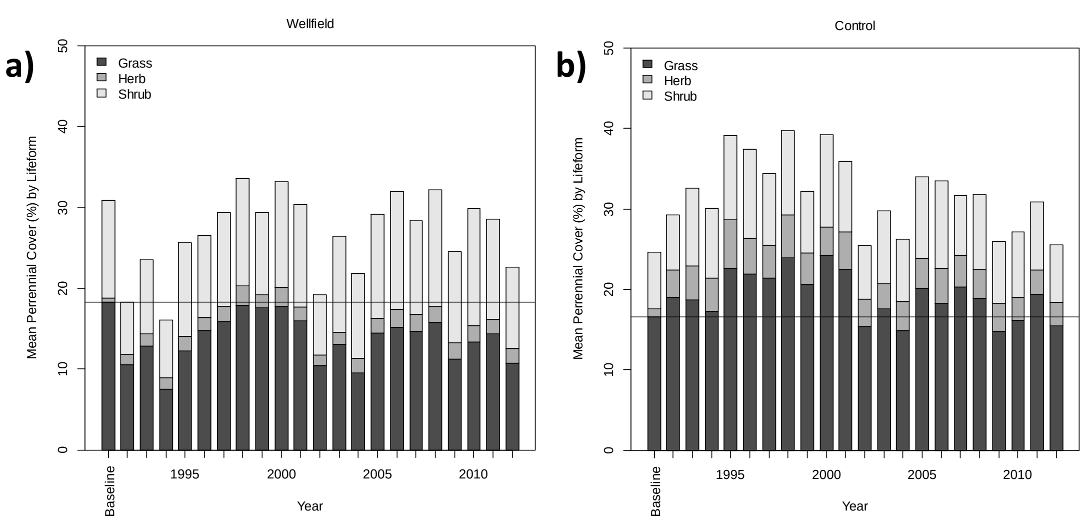

Figure 7.2. Time profile of grass, herb and shrub cover for baseline and each reinventory year for the continuously sampled control and wellfield parcels, sampled each year between 1992 and 2012 (n = 24 wellfield parcels, n = 12 control parcels, n = 22 yrs including nominal baseline year). Horizontal line shows the mean baseline grass cover value.

Difference in 2012 vs. baseline cover for wellfield and control groups—Paired t-test results

In 2012, mean perennial cover in wellfield parcels calculated from the full transect data set (n = 99) was 22.8%, a significant decline (11.4%) from the mean baseline of 34.2% (n = 63, p < 0.0001, Figure 7.3a). Mean perennial cover in control parcels calculated from the full data set in 2012 was 25.4%, a significant decline (4.9%) from the mean baseline of 30.4% (n = 36, p = 0.0186, Fig 3b).

In 2012, mean perennial grass cover in wellfield parcels calculated from the full transect data set (n = 99) was 11.1%, a significant decline (11.7%) from the mean baseline of 22.7% (n = 63, p < 0.0001, Figure 7.3a). Mean perennial grass cover in control parcels calculated from the full data set in 2012 was 13.3%, a significant decline (8.0%) from the mean baseline of 21.4% (n = 36, p = 0.0006, Figure 7.3b).

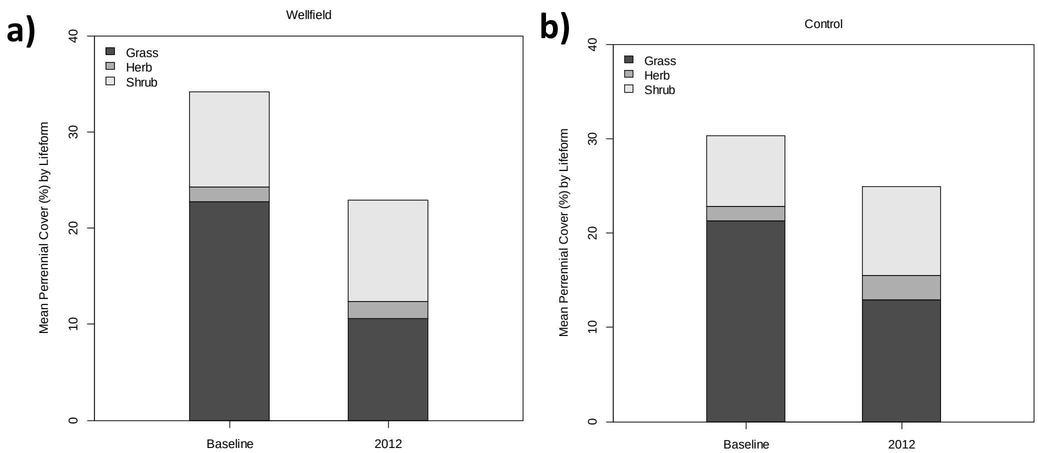

Figure 7.3. Mean perennial cover partitioned by lifeform for baseline and 2012 calculated for all parcels sampled in 2012 that have baseline transect data (n = 99). (a) Wellfield group. (b) Control group.

Differences in rates of composition change for wellfield vs. control groups—ANCOVA

Formal tests for difference in slope over time between control and wellfield were not significant for total perennial cover, grass cover, or herb cover (ANCOVA, n = 22 yrs, p = 0.2132, 0.5979 and 0.1924 respectively). The slope of mean perennial shrub cover over time in wellfield parcels was significantly different than shrub cover over time in control parcels (ANCOVA, n = 22 yrs, p = 0.0586).

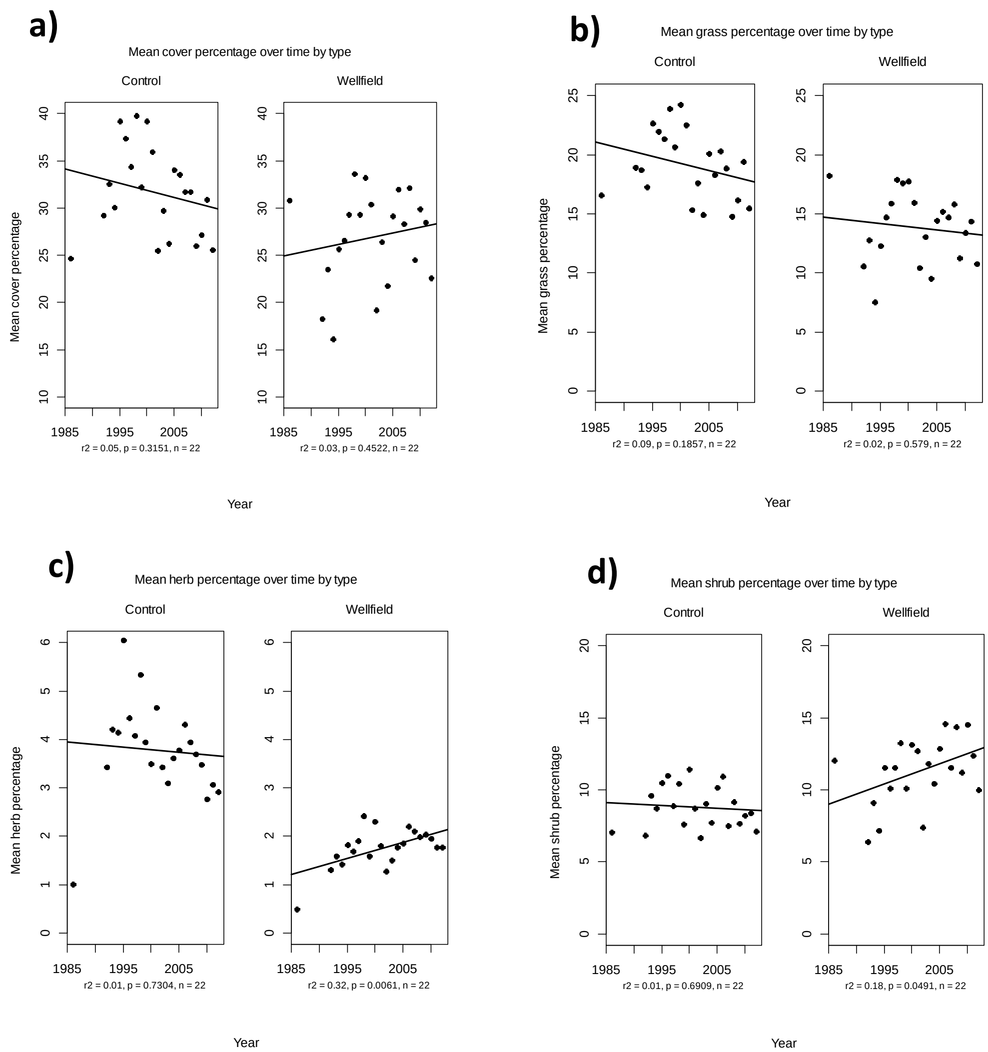

Figure 7.4. Perennial cover (a), grass cover (b), herbaceous cover (c), and shrub cover (d) over time in wellfield and control parcels computed from parcels in the continuous transect data set (n = 24 wellfield parcels, 12 control parcels, n = 22 years including nominal baseline year).

Composition change for wellfield and control groups —simple linear regression

Using the continuous data (*n* = 24 for wellfield parcels, *n* = 12 for control parcels), simple linear regression was used to assess linear trends over time. Mean perennial cover on time was not statistically significant in control parcels (R^2 = 0.05, *p* = 0.3151, *n* = 22 yrs, Figure 7.4a) or wellfield parcels (*n* = 22 yrs, R^2 = 0.03, *p* = 0.4522, Figure 7.4a). Mean perennial grass cover on time was not statistically significant for control parcels (*n* = 22 yrs, R^2 = 0.09, *p* = 0.1857, Figure 7.4b), or wellfield parcels (*n* = 22 yrs, R^2 = 0.02, *p* = 0.579, Figure 7.4b). Mean perennial herb cover on time was not statistically significant in control parcels (*n* = 22 yrs, R^2 = 0.01, *p* = 0.7304, Figure 7.4c) but was in wellfield parcels (*n* = 22 yrs, R^2 = 0.32, *p* = 0.0061, Figure 7.4c). Mean perennial shrub cover on time was not statistically significant in control parcels (n = 22 yrs, R^2 = 0.01, p = 0.6909, Figure 7.4d) but was in wellfield parcels (n = 22 yrs, R^2 = 0.18, p = 0.0491, Figure 7.4d).

Individual parcel analysis

Difference in 2012 vs. baseline cover for individual parcels—Weighted ANOVA with Dunnet's pairwise comparison

In 2012, perennial cover in 26 out of 63 wellfield parcels (41%) with baseline transect data were significantly below baseline. Appendix 2 contains every individual parcel (n = 169) sampled between baseline and 2012 and associated results of (1) weighted ANOVA on cover for the entire time period (baseline-2012) followed by Dunnet's pairwise comparison (2) SMA cover values for baseline through 2011 and (3) DTW values for baseline through 2010. This appendix will be updated with current SMA and DTW values when the data become available.

Trends in individual parcel composition change—simple linear regression

Shrub proportion in 35 of 82 parcels (regression data set, n = 49 wellfield, n = 32 control) was significantly correlated with time (Appendix 3). Seven of these 35 parcels had significantly decreasing shrub proportion and 28 parcels had significantly increasing shrub proportion (Appendix 2). Seventeen of the parcels that showed increasing shrub proportion over time were wellfield parcels while 11 were control parcels.

Grass proportion in 37 of 82 parcels was significantly correlated with time (Appendix 3). Thirty of these 37 parcels had significantly decreasing grass proportion and seven parcels had significantly increasing grass proportion (Appendix 3). Seventeen of the parcels that showed decreasing grass proportion over time were wellfield parcels while 13 were control parcels.

Herb proportion in 12 of 82 parcels was significantly correlated with time (Appendix 4). Nine of these 12 parcels had significantly increasing herb proportion and three parcels had significantly decreasing herb proportion (Appendix 3). Six of the parcels that showed increasing herb proportion over time were wellfield parcels while three were control parcels.

Some wellfield parcels that exhibited no statistically significant change in total perennial cover evaluated from the weighted ANOVA and Dunnet's multiple comparison, did have a statistically significant change in composition evaluated using simple linear regresssion. Wellfield parcels in which a significant change in cover was not detected but in which a statistically significant increase in shrub cover was detected included: BLK044, BLK142, FLS065, FSL116, FSP006, IND011, IND029, IND035, IND132, and TIN050. For each of these 10 parcels a corresponding significant decrease in grass cover was evident (p < 0.05) with the exception of IND011, being marginally significant (p = 0.06) (Appendix 3).

Significant changes in perennial cover and shrub proportion in individual wellfield parcels are summarized below along with corresponding maps of the parcel locations. In Figures 7.5-7.9, the 13 parcels that had no baseline transect data and could not be evaluated with weighted ANOVA, were grouped into the no difference from baseline category.

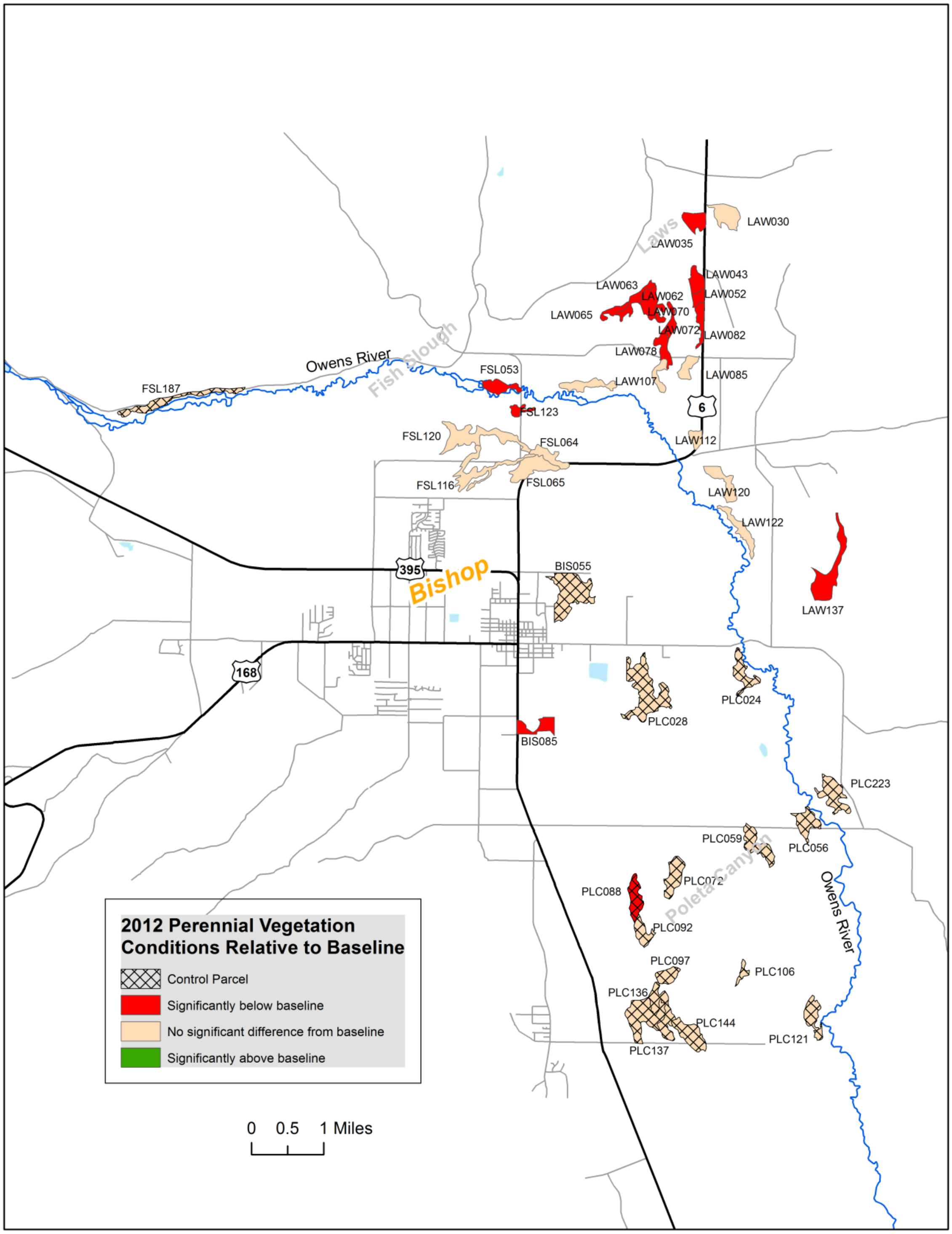

Figure 7.5. Parcels in the Bishop and Laws wellfield areas are color-coded by statistical difference relative to baseline according to 2012 results using a weighted ANOVA followed by Dunnett's comparisons to a control group method. Additionally shrub cover in FLS065 and FSL116 significantly increased over time.

Laws wellfield

In 2012, 11 out of 18 wellfield parcels (61%) were significantly below baseline in the Laws wellfield. Five were originally classified as alkali meadow: LAW035 (below baseline for the last 10 consecutive years), LAW052 (below baseline for all 17 years sampled), LAW065 (below baseline for the last four consecutive years), LAW072 (below baseline for the last six consecutive years), and LAW078 (below baseline for the last four consecutive years). One was classified as desert greasewood scrub: LAW063. Three were classified as rabbitbrush meadow: LAW062 (below baseline for the last 12 consecutive years), LAW082 (below baseline in 15 of 17 years sampled and the last four consecutive years), and LAW137. Finally, two were classified as rush/sedge meadow: LAW043 (below baseline in each of nine years sampled since 2003) and LAW070 (below baseline in all seven years it was sampled) (Figure 7.5).

Bishop wellfield

In 2012, three out of seven (43%) wellfield parcels were significantly below baseline in the Bishop (BIS) wellfield. Two were classified as alkali meadow: FSL053 and FSL123. One was classified as rabbitbrush meadow: BIS085 (Figure 7.5). Additionally shrub cover in FLS065 and FSL116 significantly increased over time (Appendix 3). In summary, 71% of the Bishop wellfield parcels were either below baseline perennial cover or had increasing shrub proportion.

Big Pine wellfield

In 2012, two out of seven (29%) wellfield parcels were significantly below baseline in the Big Pine (BGP) wellfield. One was classified as Nevada saltbush meadow: BGP154. One was classified as Nevada saltbush scrub: BGP162 (below baseline in 19 out of 22 yrs since 1991 and consecutively for the last four years) (Figure 7.6). Additionally shrub cover in FSP006 significantly increased over time (Appendix 3). In summary, 43% of the Big Pine wellfield parcels were either below baseline perennial cover or had increasing shrub proportion.

Taboose-Aberdeen Wellfield

In 2012, five out of 14 (36%) wellfield parcels were significantly below baseline in the Taboose-Aberdeen (TA) wellfield. Four were classified as alkali meadow: BLK009, BLK033, TIN064, and TIN068. One was classified as Nevada saltbush scrub: BLK021 (below baseline in 14 of 18 reinventory years and consecutively for the last six years) (Figure 7.7). Additionally shrub cover in BLK044, BLK142, and TIN050 significantly increased over time (Appendix 3). In summary, 57% of the Taboose-Aberdeen wellfield parcels were either below baseline perennial cover or had increasing shrub proportion.

Thibaut-Sawmill Wellfield

In 2012, four out of 13 (31%) wellfield parcels were significantly below baseline in the Thibaut-Sawmill (TS) wellfield. Two were classified as alkali meadow: BLK075 and BLK094 (below baseline in 16 of the last 22 reinventory years and consecutively for the last nine years). Two were classified as desert sink scrub: BLK077 and BLK096 (Figure 7.7). Additionally shrub cover in IND029 and IND035 significantly increased over time (Appendix 3). In summary, 46% of the Thibaut-Sawmill wellfield parcels were either below baseline perennial cover or had increasing shrub proportion.

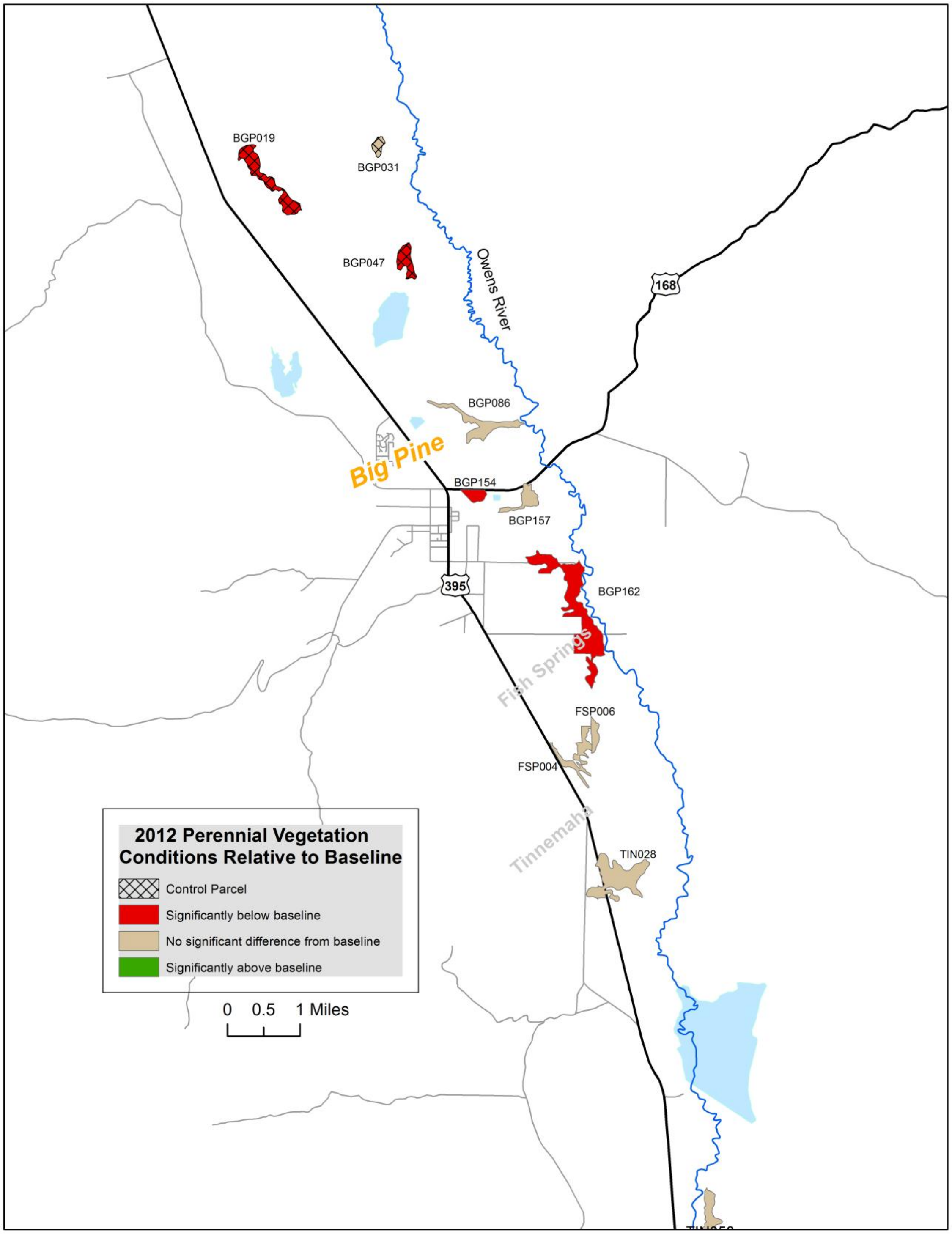

Figure 7.6. Parcels in the Big Pine wellfield area are color-coded by statistical difference relative to baseline according to 2012 results using a weighted ANOVA followed by Dunnett's comparisons to a control group method. Additionally shrub cover in FSP006 significantly increased over time.

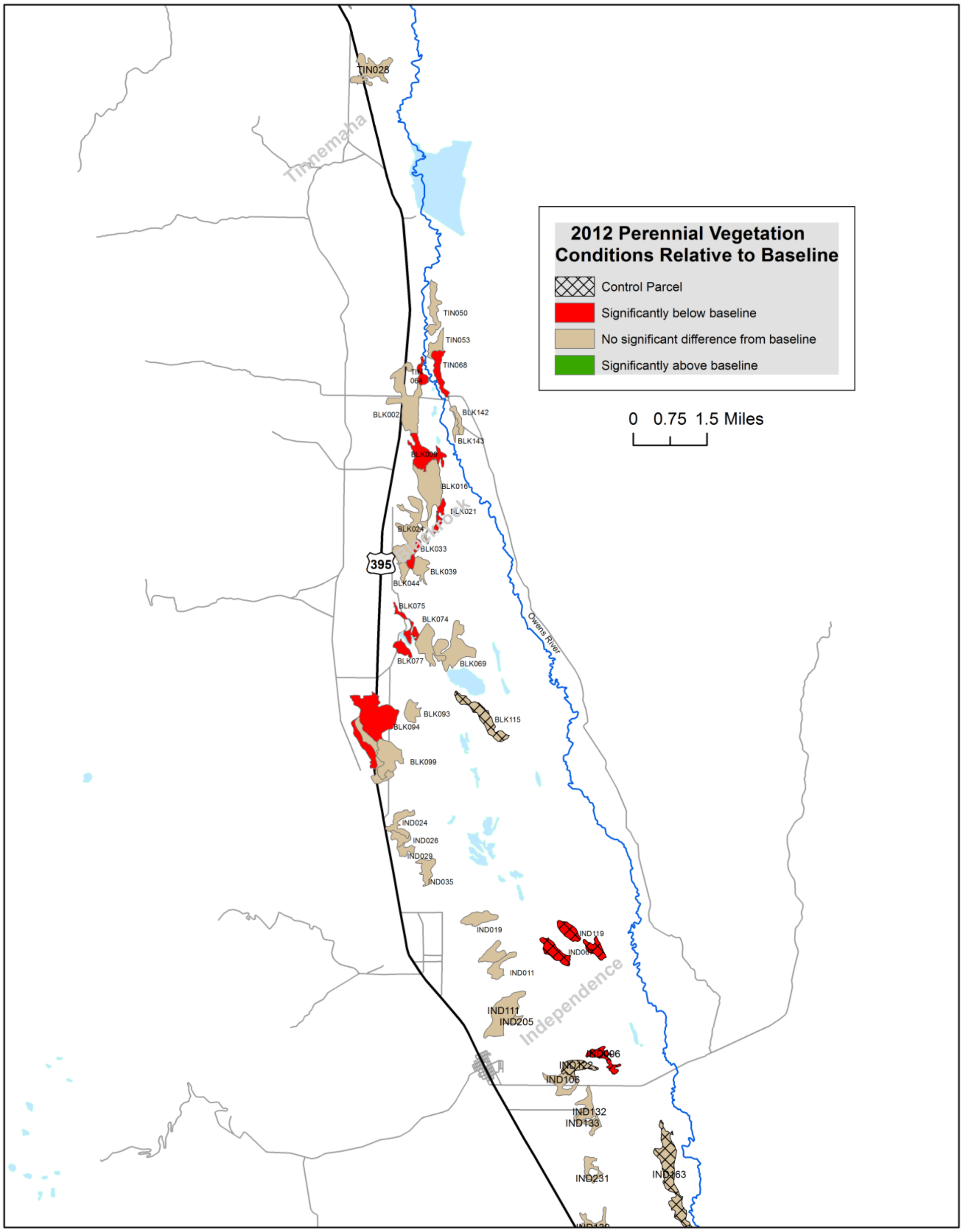

Figure 7.7. *Parcels in the Taboose-Aberdeen and Thibaut-Sawmill wellfield areas are color-coded by statistical difference relative to baseline according to 2012 results using a weighted ANOVA followed by Dunnett's comparisons to a control group method. Additionally shrub cover in BLK044, BLK142, TIN050, IND029 and IND035 significantly increased over time.*

Independence-Oak Wellfield

Shrub cover in parcel IND011 significantly increased over time (Appendix 3). In summary, one out of six (17%) of the Independence-Oak wellfield parcels had increasing shrub proportion (Figure 7.8).

Symmes-Shepard Wellfield

Shrub cover in parcel IND132 significantly increased over time (Appendix 3). In summary, one of six (17%) of the Symmes-Shepard wellfield parcels had increasing shrub proportion (Figure 7.8).

Bairs-Georges Wellfield

In 2012 the only wellfield parcel, MAN037, in Bairs-Georges wellfield, was not below baseline perennial cover nor did it have increasing shrub cover (Figure 7.8).

Lone Pine Wellfield Wellfield

In 2012, perennial cover in the only wellfield parcel in the Long Pine (LP) wellfield, classified as Nevada saltbush meadow, was significantly below baseline: LNP045 (Figure 7.9).

Control parcels below baseline cover

There were 10 control parcels that were statistically below baseline cover: PLC088, BGP047, BGP019, IND064, IND119, IND067, IND096, IND151, MAN014, and LNP050.

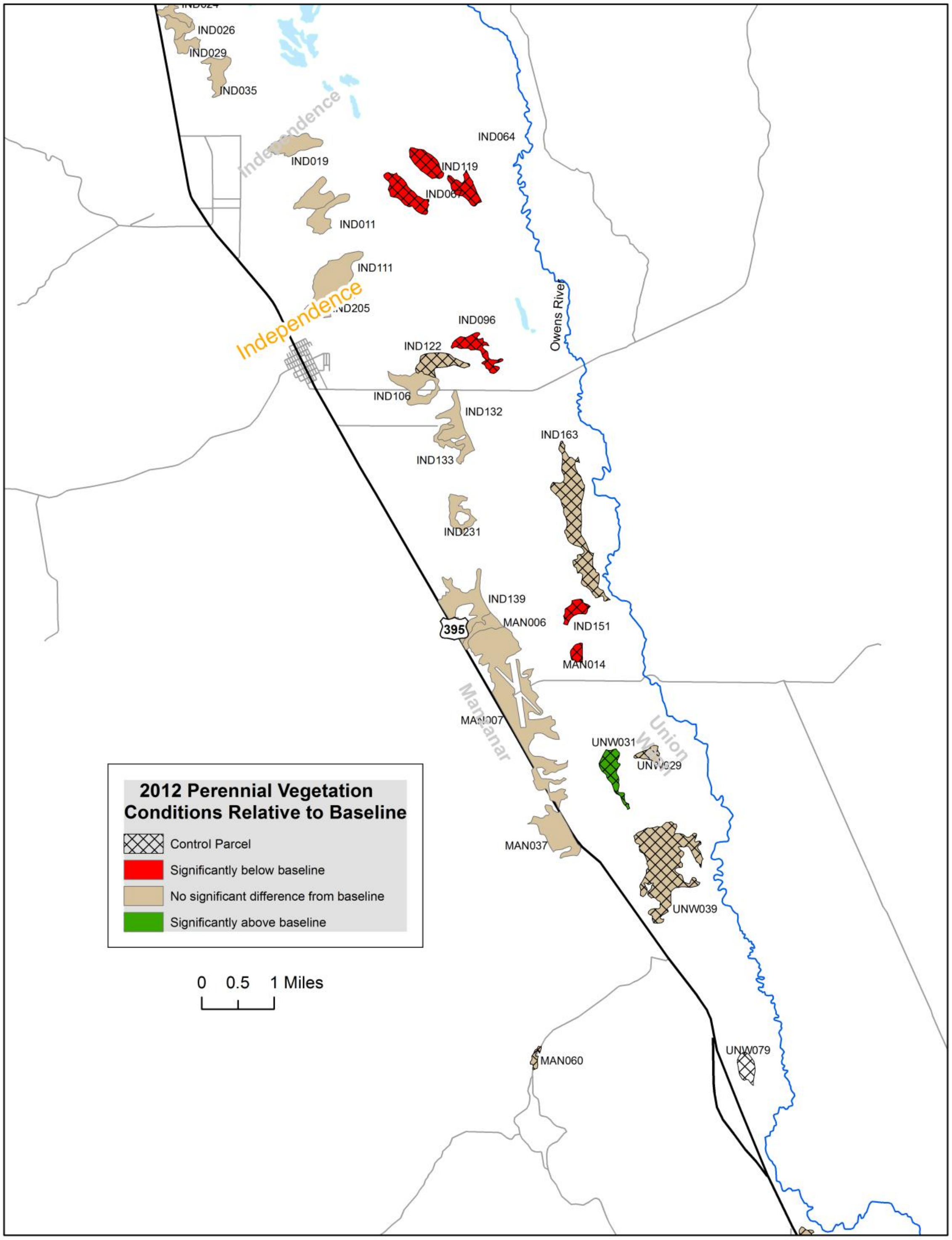

Figure 7.8. Parcels in the Independence-Oak, Symmes-Shepard and Bairs-Georges wellfield areas are color-coded by statistical difference relative to baseline according to 2012 results using a weighted ANOVA followed by Dunnett's comparisons to a control group method. UNW079 was not sampled in 2012 due to flooding. Additionally shrub cover in IND011 and IND132 significantly increased over time.

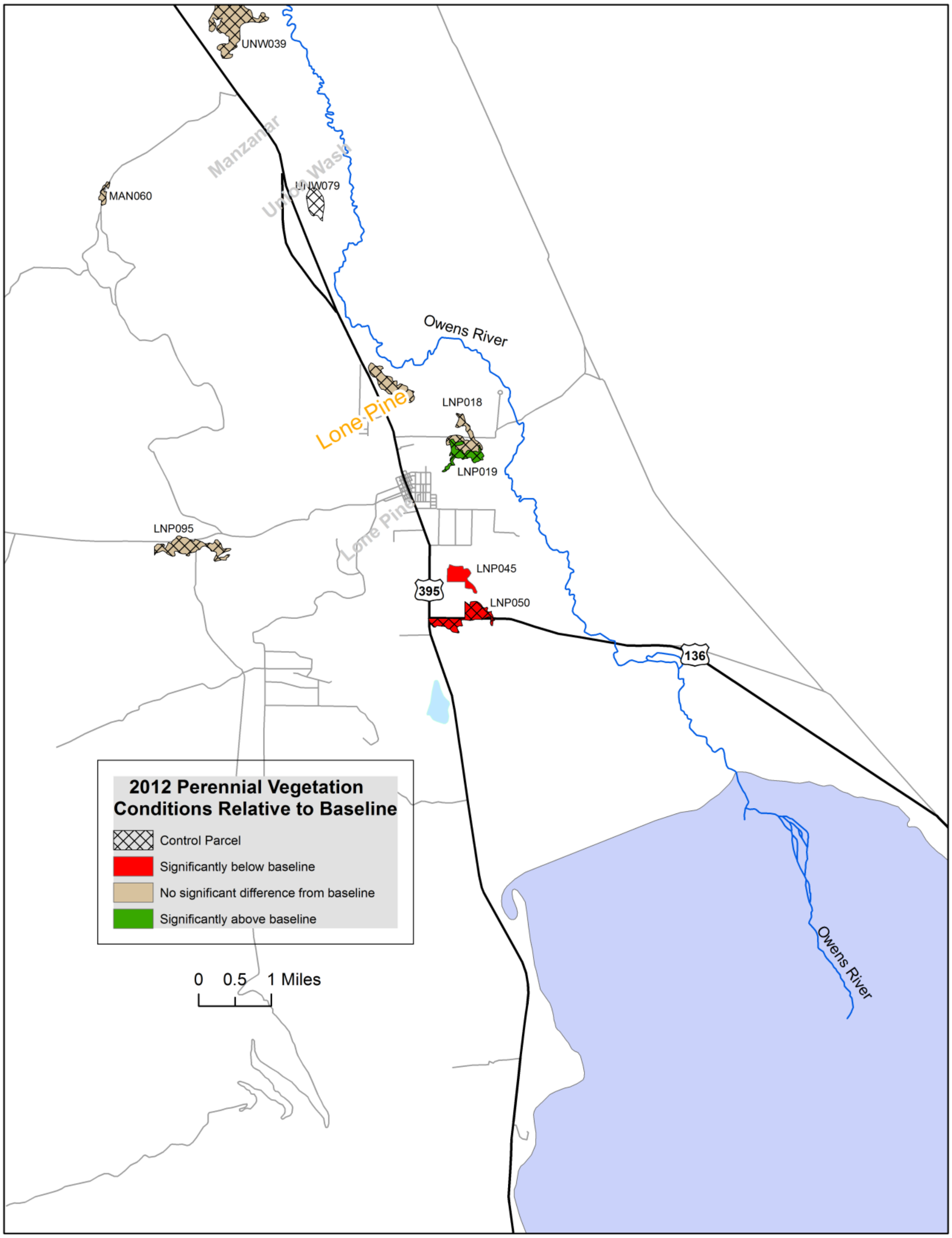

Figure 7.9. Parcels in the Lone Pine wellfield areas are color-coded by statistical difference relative to baseline according to 2012 results using a weighted ANOVA followed by Dunnett's comparisons to a control group method.

Discussion

In general, there have been statistically significant cover and composition changes at the aggregated wellfield and control group level and also for individual parcels. The majority of the individual parcels that had statistically significant change were from the wellfield group.

Analysis of parcel groups: wellfield vs. control

Comparison of change profiles between wellfield and control groups

The change from baseline of mean perennial cover of wellfield parcels from 1992-2012 differed significantly from the change from baseline of mean perennial cover of control parcels. The finding of statistical significance for this test could in theory be due to either shape or level differences between the change profile of wellfield and control parcels. The shape of the change profile was quite similar for both parcel groups and thus the significance may be interpreted as being due to differences in overall level, with the wellfield group change from baseline, significantly below that of the control group.

Difference in 2012 vs. baseline cover for wellfield and control groups

The significant decrease in both total cover and grass cover in wellfield and control groups is likely an effect of multiple factors. Some decrease in vegetation cover is expected in dry years, though cover in the wellfield group decreased more than twice that of control parcels (11.37% compared to 4.94%). The decline in grass cover was also greater in the wellfield group compared to the control group (11.65% decrease compared to 8.03% in control parcels). It is possible for the grass component to decline more than the total change in cover because shrub cover simultaneously increased in wellfield parcels and shrub and herb cover increased in control parcels (see below).

Composition change for wellfield and control group

Using the continuous data set, simple linear regression showed shrub and herb cover in wellfield parcels increased significantly and did not change in control parcels. Some baseline values have high leverage in the regressions and thus significant change during the reinventory period may have been masked with the inclusion of baseline values that fell outside the linear trend during the reinventory period. These regressions suffer from small sample sizes, especially the control group, with only 12 parcels used to calculate the annual means for the regression. Even with low sample size for wellfield parcels (n = 24), however, the correlation with shrub cover was strong, showing consistent increases over the reinventory period. A linear model, however, did not explain variation in grass cover over time in contrast to findings from the full data set—that grass cover is significantly below baseline in 2012.

In the case of grass cover, a linear model is mechanistically inappropriate for modeling long-term vegetation composition, but is adequate for quantitative description of short-term trends. The period over which linearity should hold would be during grass cover decline in association with water table drawdown beyond the root zone or grass cover increase in association with water table recovery. When there are several episodes of both water table drawdown and subsequent recovery within a time period of interest, the expectation is for grass cover to lag behind the water table drawdown accounting for biological processes of dieback and regrowth. A simple linear model would not capture these ecohydrological linkages and indicate erroneously that change was not linked to water table drawdown when assessed over a time period with fluctuations in water table level. For example, Jabis (2012) discussed why a linear model may not have captured variation in grass cover in wellfield parcels:

"Lack of correlation with grass cover and time in wellfield parcels during the entire time period [baseline-2011] may be due to increased runoff and low pumping between the years 1995-1998. Although grass cover is currently below baseline and has remained in that condition since the 2001 growing season, recovery between 1997 and 2000 stabilized grass cover change for a period of approximately four years restoring cover to near baseline conditions".

Thus fluctuations in pumping level or other environmental factors and not time *per se* drive change in composition. And the appropriateness of linear models to describe shrub, herb or grass cover over time is predicated on time covarying with the salient entities and rates of processes that directly limit population demographics.

With a decline in grass owing to a drop in the ground water table, shrub establishment is predicted to increase. Subsequent recovery of the water table may partially recover the grass component. Yet, deep-rooted shrubs may not decline with subsequent water table drawdown beyond the grass root zone. Each additional drawdown beyond the grass root zone may further facilitate shrub infilling and loss of the grass component. This hypothesis is consistent with the observed linear increase in shrub proportion over time, while grass cover is more strongly dependent on the fluctuating degree of ground-water pumping and consequently whether the water table is adequate to wet the shallow rooting zone.

Individual parcel analysis

Difference in 2012 vs. baseline cover for individual parcels

All wellfield areas in the valley contain one or more parcels with reduced perennial cover in 2012 except for Independence-Oak, Symmes-Shepard, and Bairs-Georges wellfields. In total, 26 wellfield and 10 control parcels were below baseline cover values. Roughly half (53%) of the parcels below baseline are alkali meadow. Another 30% are other meadow types: rush/sedge meadow, rabbitbrush meadow, Nevada saltbush meadow.

Dominant species in these meadow communities require more water than is available via precipitation and thus obtain needed water within a zone of soil that is saturated with groundwater, or immediately above this zone in the capillary fringe. Reduction in water table beyond a maximum rooting depth of 2-2.5 m is incompatible with shallow-rooted species of meadow ecosystems. With water-table reductions, establishment and dominance of deep-rooted woody species is predicted based on empirical evidence and theory (Stromberg et al. 1996; Cooper et al. 2006; Trammell et al. 2008; Goedhart and Pataki, 2010). In alkali soils, reductions in the groundwater table reduce dissolved salt content that accumulates via wicking to the surface via capillary action (Cooper et al. 2006; Patten et al. 2008). In addition to a lack of salt replenishment to the soil surface with water table reductions, subsequent precipitation events further leach remaining salts to deeper horizons. The consequent decreases in soil salt content could increase site-suitability for non-halophytic species (Patten et al. 2008) and reduce site-suitability for halophytes (plants adapted to saline environments). *Distichlis spicata*, or saltgrass, a native halophytic dominant of alkali meadow, could be expected to decrease in distribution and abundance in association with both decreases in the groundwater table and consequent decreases in soil-surface salt content. To allow long-term persistence of meadow ecosystems and alkali meadow in particular, water management in the Owens Valley requires maintenance of a shallow saturated zone of soil necessary to maintain populations of meadow species.

Trends in individual parcel composition change

The decrease in grass cover and increase in shrub cover in the wellfield parcels is consistent with the causal link between water table reductions beyond the 2 to 2.5-m grass root zone, favoring deeper-rooted woody shrubs. Control parcels, however, also increased shrub cover in 11 of 33 parcels and decreased grass cover in 13 of 33 parcels. Since control parcels are outside the influence of ground-water pumping, the mechanism underlying this effect could be due to other factors associated with altered disturbance regimes (i.e. grazing, fire, and drought) (Brown and Archer 1999, Van Auken 2000, Berlow *et al.* 2002, Eldridge *et al.* 2011).

For parcels influenced by groundwater management, repeated drawdown below the maximum rooting depth of grasses may result in establishment and dominance of shrubs. Depending on the degree of grass decline, water management alone may be inadequate to recover the former grass component without additional management such as prescribed fire and reseeding. Land and water management practices, including reduced pumping in impacted areas, in combination with water spreading, prescribed burning (to reduce woody vegetation) and revegetation of alkali meadow species where appropriate may allow recovery of ground-water dependent meadows at sites already transitioning to woody-dominated communities. Lack of action in arresting these transitions during early warning signs of composition shifts, will require more intensive action later on with the likelihood of success shrinking rapidly as the local species pool is reduced.

Limitations of control and wellfield group aggregation as a monitoring metric

Here, there is a need to highlight an important distinction between the terminology given to control parcels and the term “control” in the experimental sense. A control in the experimental sense is typically measured to disentangle the effect of a treatment from the effects of other unmeasured factors. If the effect of these factors is negligible between the control and treatment groups, then the difference in the response variable can normally be attributed to the treatment effect. The parcel designations into wellfield or control were based in essence on their proximity to wellfields. Other factors however cannot be controlled in this context because the optimum locations for wellfields are on the toe slopes of alluvial fans and few if any suitable control parcels unaffected by pumping are located within this landscape position. By default, control parcels are generally located east of wellfield parcels, further into the interior of the valley. Differences in landuse and soil type are among the factors that make treating the control group as an experimental control problematic. Another disadvantage of the wellfield vs. control group comparison is that the group means are averaged over many parcels of different plant community types, edaphic characteristics, and degree of ground water pumping influence. Effectively, in computing average cover across these different parcels, much of the site-specific information is smoothed over. Importantly, it is the individual parcels that are influenced by their proximity to pumping wells and how the rate of pumping translates to water table levels for a given parcel. This spatial information that is critical for water management at the individual pumping well and individual parcel scale is lost when cover values are aggregated to the wellfield/control group scale. In terms of water management, the individual parcel would appear to be the logical scale at which to assess significant changes in vegetation with respect to site-specific water management spatially associated with the specific parcel.

Conclusions

Vegetation conditions following the 2012-monitoring season can be summarized by four main findings. First, during the time period 1992-2012, the change profile of the wellfield parcel group was different from the control parcel group, with the decrease in wellfield group cover below that of the control group. Second, overall perennial cover and grass cover in 2012 for both wellfield and control parcel groups was significantly below baseline. The perennial cover decrease in the wellfield parcel group was more than twice the decrease in the control group (11.4% vs. 4.9%)(Fig 3a-b). Third, within the wellfield parcel group, the relative proportion of shrub cover has significantly increased. Finally at the individual parcel level of analysis, 57% of wellfield parcels were either significantly below their baseline cover values (41%) or had significant increases in shrub cover (16%).

Acknowledgments

Field data collection and data management was conducted by Jerry Zatorski, Meredith Jabis, Sally Manning and a dedicated field crew during the reinventory period covered in this report (1991-2012). The structure of the report including the analytical approach was modeled after the 2011 report by Meredith Jabis. Sally Westmoreland assisted with GIS map creation and database queries. Mike Baffrey assisted with SQL code and Jerome Braun developed R code and provided statistical consulting for the analyses.

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Vegetation Section Appendices

Appendix 1. Parcels sampled in 2012. Column headings indicate: wellfield or control status, *W/C*; plant community type based on Holland (1986), *Plant Community*; number of acres in the parcel, *Acres*; presence of baseline transect data, *BaseTransData*; presence of Greenbook line point data during the entire time period from 1992-2011, *LPT'92-2011*; and presence of line point data during the complete reinventory period from 1991-2011, *LPT'91-2011*.

Appendix 2. Figures 1-169 show mean perennial vegetation cover plotted over time for the 169 vegetation parcels sampled since 1991 using the Green Book Line Point monitoring program, and SMA average cover data (through 2011), and depth to water (through 2010). Asterisks depict years that perennial cover is significantly different from the baseline period (sampled between 1984 and 1987) using a weighted ANOVA followed by Dunnett's multiple comparisons. Thirteen parcels do not have raw transect data and thus could not be analyzed with ANOVA. In these cases, the baseline cover value is shown without error bars.

Appendix 3. Shrub, herb and grass proportion regressed against time in parcels with baseline transect data and at least 10 years of line point data. Columns indicate: wellfield or control parcel status, *W/C*; sample size, *n*; coefficient of determination, R^2; p-value, *p*; slope parameter estimate, *slope*; upper and lower 95% confidence interval for the slope parameter, *95% Confidence Interval*; direction (positive or negative) of the relationship, *Slope direction*. Bold text in p-value column, indicates significant regressions at $\alpha = 0.05$.

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Appendix 1. Parcels sampled in 2012. Column headings indicate wellfield and control status *W/C*, plant community type based on Holland (1986), *Plant Community*; spatial extent of parcel, *Acres*; presence of baseline transect data, *BaseTransData*; presence of Greenbook line point data during the entire time period from 1992-2012, *LPT'92-2012*; and presence of line point data during the complete time period from 1991-2012, *LPT'91-2012*.

	Parcel	W/C	Plant Community	Acres	BaseTransData	LPT '92-2012	LPT '91-2012
1	BGP019	C	Rush/Sedge Meadow	110.2	Y		
2	BGP031	C	Alkali Meadow	19.4	Y	Y	
3	BGP047	C	Alkali Meadow	47.5	Y		
4	BIS055	C	Alkali Meadow	146.3	Y		
5	BLK115	C	Alkali Meadow	154.2	Y	Y	
6	FSL187	C	Alkali Meadow	74.2	Y	Y	
7	IND064	C	Alkali Meadow	64.5	Y		
8	IND067	C	Nevada Saltbush Meadow	96.0	Y		
9	IND096	C	Nevada Saltbush Scrub	73.5	Y	Y	Y
10	IND119	C	Alkali Meadow	73.0	Y		
11	IND122	C	Nevada Saltbush Scrub	82.3	Y		
12	IND151	C	Alkali Meadow	40.4	Y		
13	IND163	C	Alkali Meadow	301.8	Y	Y	Y
14	LNP018	C	Alkali Meadow	59.0	Y	Y	
15	LNP019	C	Nevada Saltbush Scrub	49.4	Y		
16	LNP050	C	Alkali Meadow	85.6	Y		
17	LNP095	C	Alkali Meadow	96.4	Y		
18	MAN014	C	Nevada Saltbush Meadow	22.8	Y		
19	MAN060	C	Alkali Meadow	13.5	Y	Y	
20	PLC024	C	Alkali Meadow	53.7	Y	Y	
21	PLC028	C	Alkali Meadow	170.2	Y		
22	PLC056	C	Rabbitbrush Meadow	54.1	Y		
23	PLC059	C	Nevada Saltbush Scrub	65.1	Y		
24	PLC072	C	Rabbitbrush Scrub	60.7	Y		

	Parcel	W/C	Plant Community	Acres	BaseTransData	LPT '92-2012	LPT '91-2012
25	PLC088	C	Alkali Meadow	52.7	Y		
26	PLC092	C	Rabbitbrush Scrub	38.4	Y		
27	PLC097	C	Alkali Meadow	34.3	Y		
28	PLC106	C	Rabbitbrush Meadow	14.1		Y	Y
29	PLC121	C	Alkali Meadow	52.5	Y	Y	
30	PLC136	C	Alkali Meadow	80.0	Y		
31	PLC137	C	Rabbitbrush Meadow	115.4	Y		
32	PLC144	C	Alkali Meadow	70.0	Y		
33	PLC223	C	Alkali Meadow	75.1	Y	Y	Y
34	UNW029	C	Alkali Meadow	29.7	Y	Y	
35	UNW031	C	Rush/Sedge Meadow	73.9	Y		
36	UNW039	C	Nevada Saltbush Scrub	407.4	Y	Y	Y
37	UNW074	C	Alkali Meadow	78.1	Y		
38	BGP086	W	Alkali Meadow	88.7	Y		
39	BGP154	W	Nevada Saltbush Meadow	27.9	Y	Y	Y
40	BGP157	W	Rabbitbrush Scrub	44.7	Y		
41	BGP162	W	Nevada Saltbush Scrub	286.0	Y	Y	Y
42	BIS085	W	Rabbitbrush Meadow	45.3	Y		
43	BLK002	W	Rabbitbrush Scrub	280.1	Y		
44	BLK009	W	Alkali Meadow	152.0	Y	Y	Y
45	BLK016	W	Alkali Meadow	247.8	Y	Y	Y
46	BLK021	W	Nevada Saltbush Scrub	43.5	Y		
47	BLK024	W	Nevada Saltbush Meadow	259.8	Y	Y	Y
48	BLK033	W	Alkali Meadow	37.9	Y	Y	
49	BLK039	W	Alkali Meadow	66.9	Y	Y	
50	BLK044	W	Rabbitbrush Meadow	33.6		Y	Y
51	BLK069	W	Desert Sink Scrub	234.9		Y	Y
52	BLK074	W	Nevada Saltbush Scrub	141.2		Y	

	Parcel	W/C	Plant Community	Acres	BaseTransData	LPT '92-2012	LPT '91-2012
53	BLK075	W	Alkali Meadow	55.4	Y	Y	
54	BLK077	W	Desert Sink Scrub	44.9	Y		
55	BLK093	W	Alkali Meadow	65.6	Y		
56	BLK094	W	Alkali Meadow	333.5	Y	Y	Y
57	BLK095	W	Alkali Meadow	115.1	Y		
58	BLK096	W	Desert Sink Scrub	81.7	Y		
59	BLK099	W	Alkali Meadow	170.8	Y	Y	Y
60	BLK142	W	Alkali Meadow	35.5	Y		
61	BLK143	W	Alkali Meadow	21.6	Y		
62	FSL053	W	Alkali Meadow	41.8	Y		
63	FSL064	W	Alkali Meadow	40.6	Y		
64	FSL065	W	Alkali Meadow	79.2	Y		
65	FSL116	W	Alkali Meadow	88.2	Y		
66	FSL120	W	Alkali Meadow	119.1	Y		
67	FSL123	W	Alkali Meadow	17.9	Y		
68	FSP004	W	Rabbitbrush Meadow	68.7	Y		
69	FSP006	W	Alkali Meadow	24.6		Y	Y
70	IND011	W	Alkali Meadow	71.1	Y	Y	
71	IND019	W	Alkali Meadow	90.8	Y		
72	IND021	W	Rabbitbrush Meadow	78.1	Y		
73	IND024	W	Alkali Meadow	75.8	Y		
74	IND026	W	Alkali Meadow	43.0	Y		
75	IND029	W	Alkali Meadow	35.9	Y		
76	IND035	W	Alkali Meadow	70.0	Y	Y	
77	IND106	W	Nevada Saltbush Scrub	101.4		Y	Y
78	IND111	W	Nevada Saltbush Meadow	227.8	Y	Y	Y
79	IND132	W	Nevada Saltbush Scrub	110.5		Y	Y
80	IND133	W	Nevada Saltbush Scrub	29.9			

	Parcel	W/C	Plant Community	Acres	BaseTransData	LPT '92-2012	LPT '91-2012
81	IND139	W	Nevada Saltbush Meadow	170.3	Y	Y	Y
82	IND205	W	Alkali Meadow	17.5			
83	IND231	W	Nevada Saltbush Scrub	61.5		Y	Y
84	LAW030	W	Alkali Meadow	62.7	Y		
85	LAW035	W	Alkali Meadow	43.3	Y		
86	LAW043	W	Rush/Sedge Meadow	36.5	Y		
87	LAW052	W	Alkali Meadow	18.8	Y		
88	LAW062	W	Rabbitbrush Meadow	48.6	Y		
89	LAW063	W	Desert Greasewood Scrub	37.6	Y	Y	Y
90	LAW065	W	Alkali Meadow	21.4	Y	Y	
91	LAW070	W	Rush/Sedge Meadow	15.5	Y		
92	LAW072	W	Alkali Meadow	24.2	Y		
93	LAW078	W	Alkali Meadow	38.9	Y		
94	LAW082	W	Rabbitbrush Meadow	30.2	Y		
95	LAW085	W	Alkali Meadow	32.5		Y	Y
96	LAW107	W	Alkali Meadow	28.3	Y	Y	
97	LAW109	W	Alkali Meadow	49.0	Y		
98	LAW112	W	Nevada Saltbush Meadow	22.2	Y		
99	LAW120	W	Alkali Meadow	53.9	Y	Y	Y
100	LAW122	W	Alkali Meadow	50.4	Y	Y	
101	LAW137	W	Rabbitbrush Meadow	108.4	Y		
102	LNP045	W	Nevada Saltbush Meadow	48.9	Y		
103	MAN006	W	Alkali Meadow	47.9	Y	Y	
104	MAN007	W	Nevada Saltbush Scrub	565.2	Y	Y	Y
105	MAN037	W	Nevada Saltbush Scrub	146.4	Y	Y	Y
106	TIN028	W	Desert Greasewood Scrub	163.8	Y	Y	Y
107	TIN050	W	Alkali Meadow	102.7	Y		
108	TIN053	W	Alkali Meadow	53.4	Y		

	Parcel	W/C	Plant Community	Acres	BaseTransData	LPT '92-2012	LPT '91-2012
109	TIN064	W	Alkali Meadow	42.0	Y		
110	TIN068	W	Alkali Meadow	84.6	Y	Y	

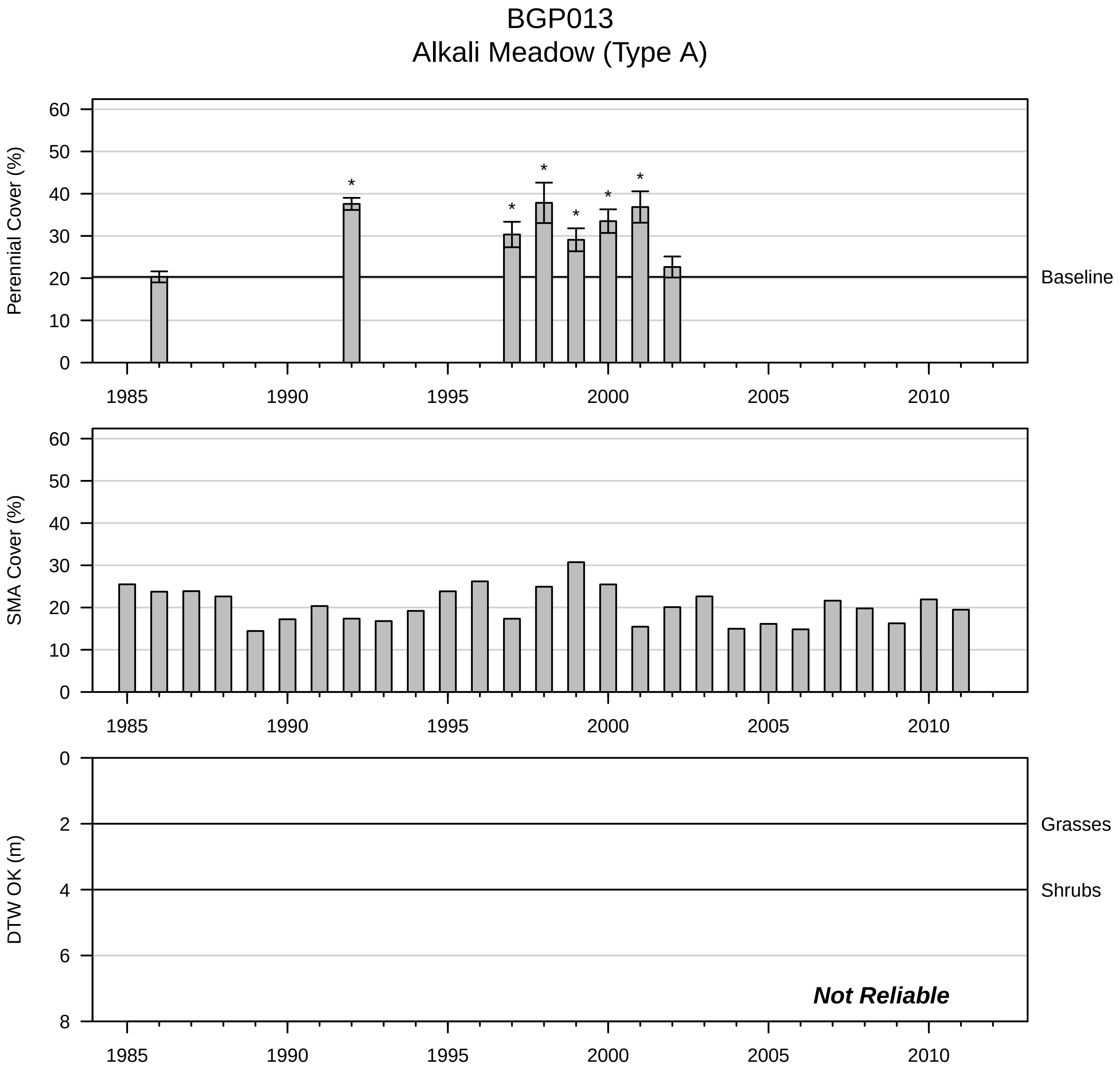


Figure 1: 2002 Control

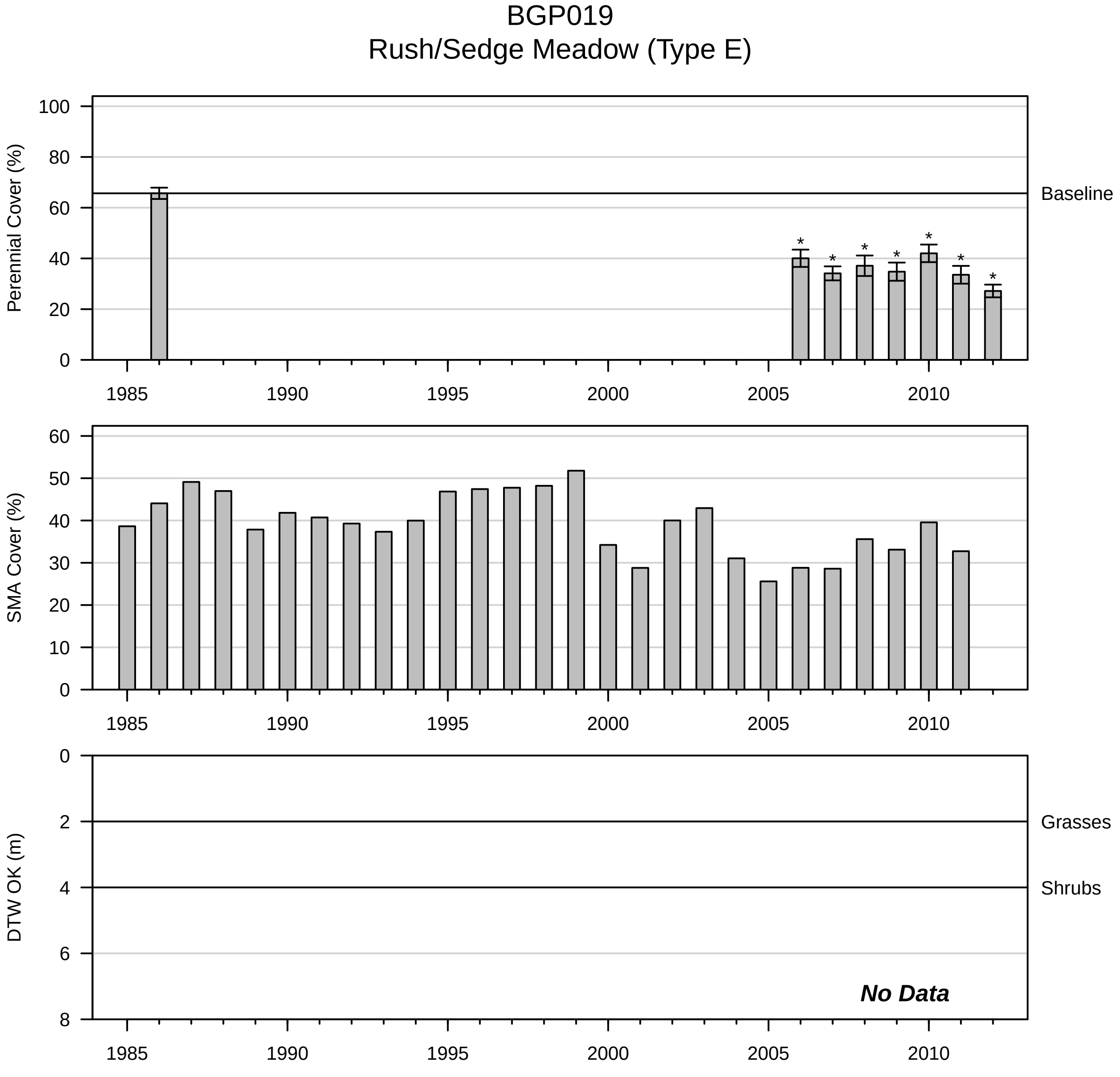


Figure 2: 2012 Control

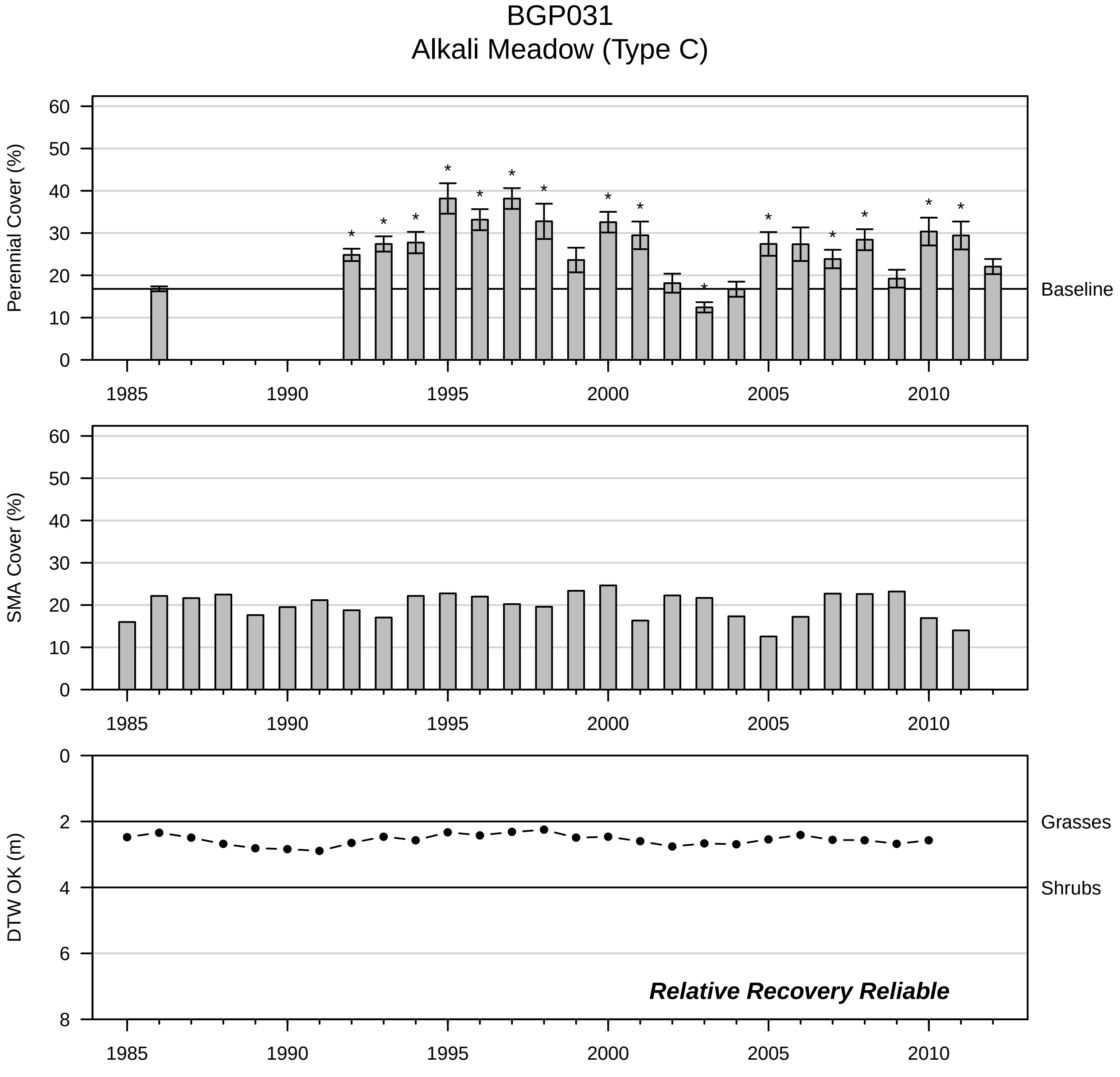
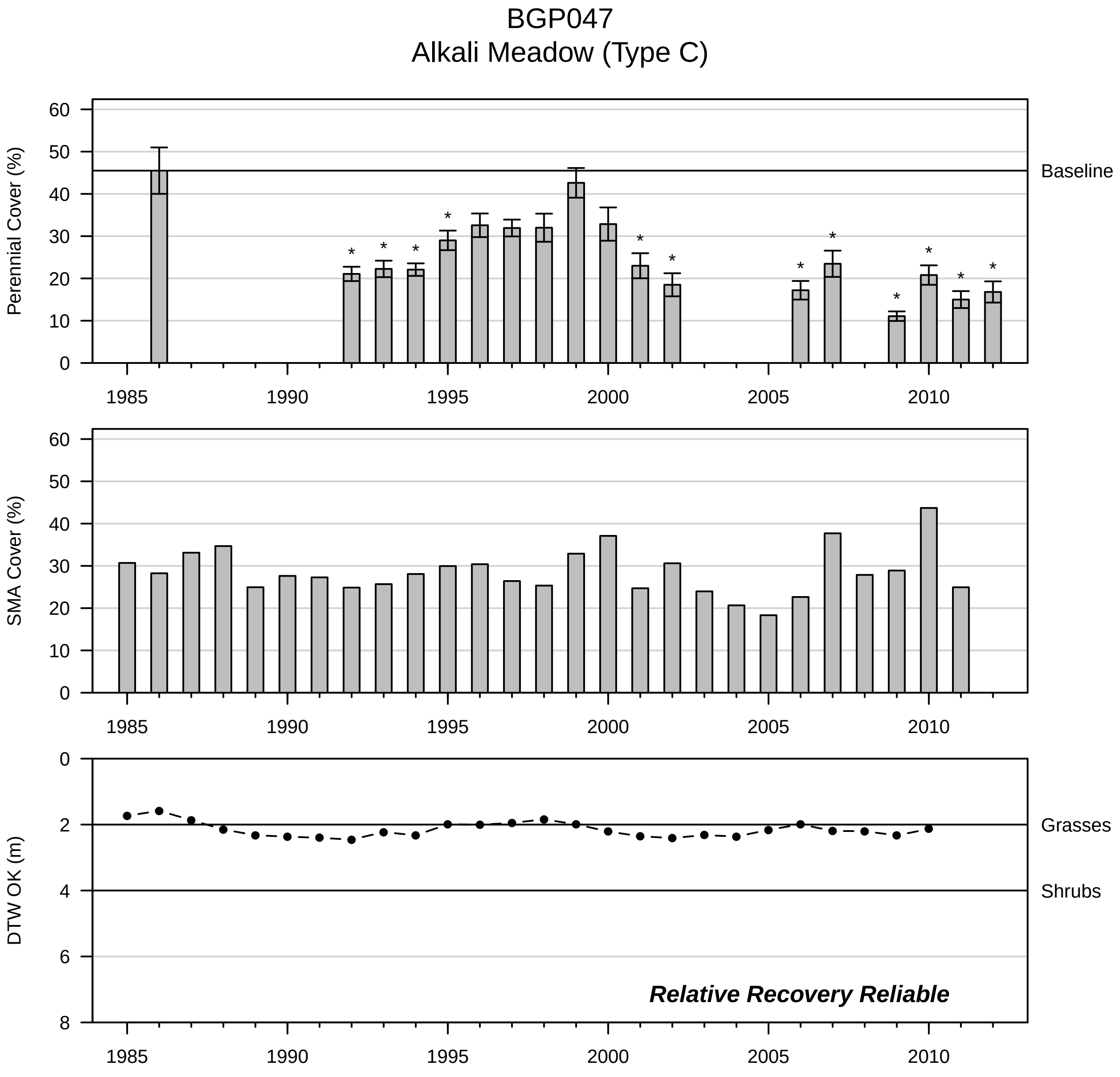


Figure 3: 2012 Control



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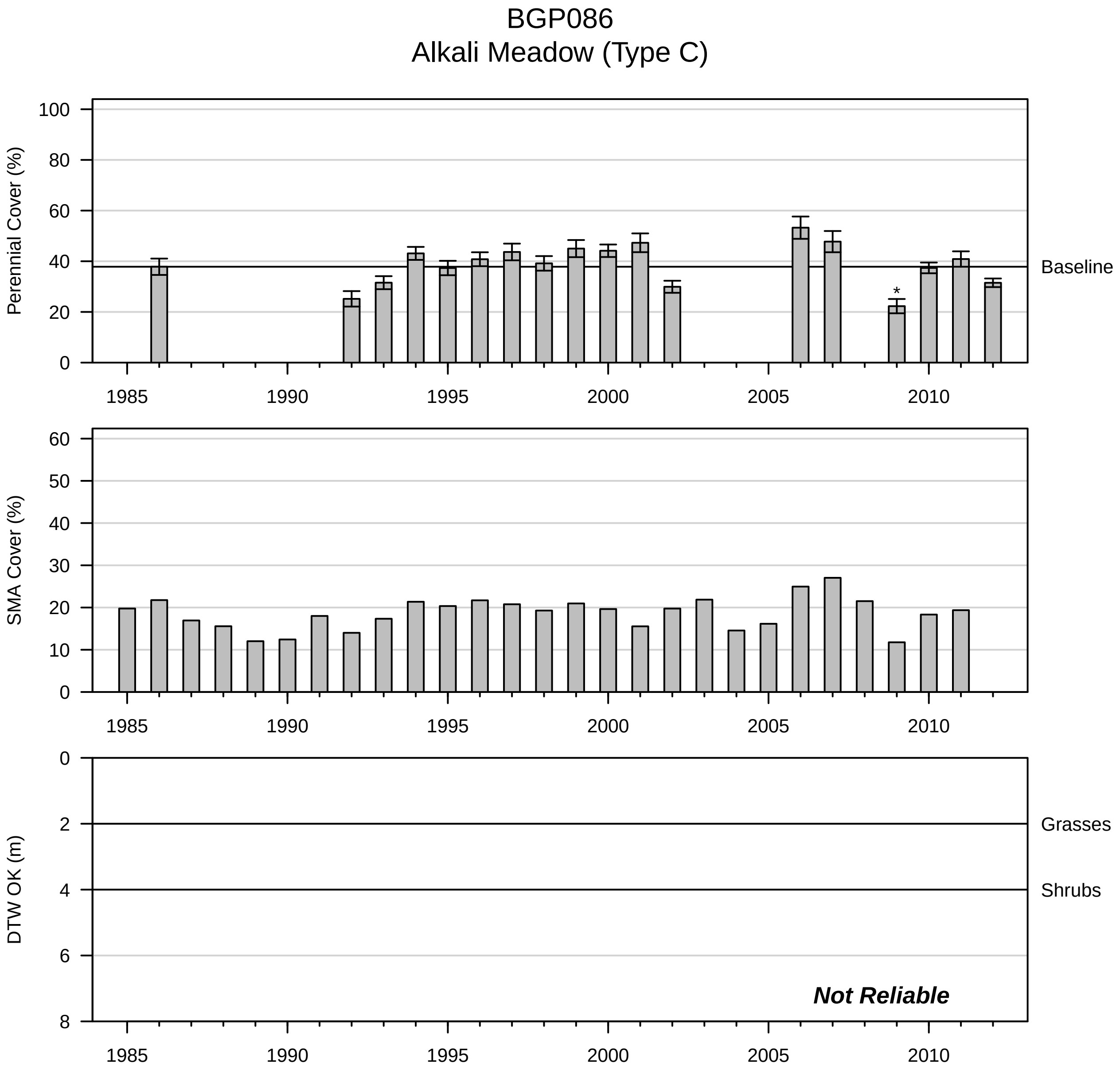


Figure 5: 2012 Wellfield

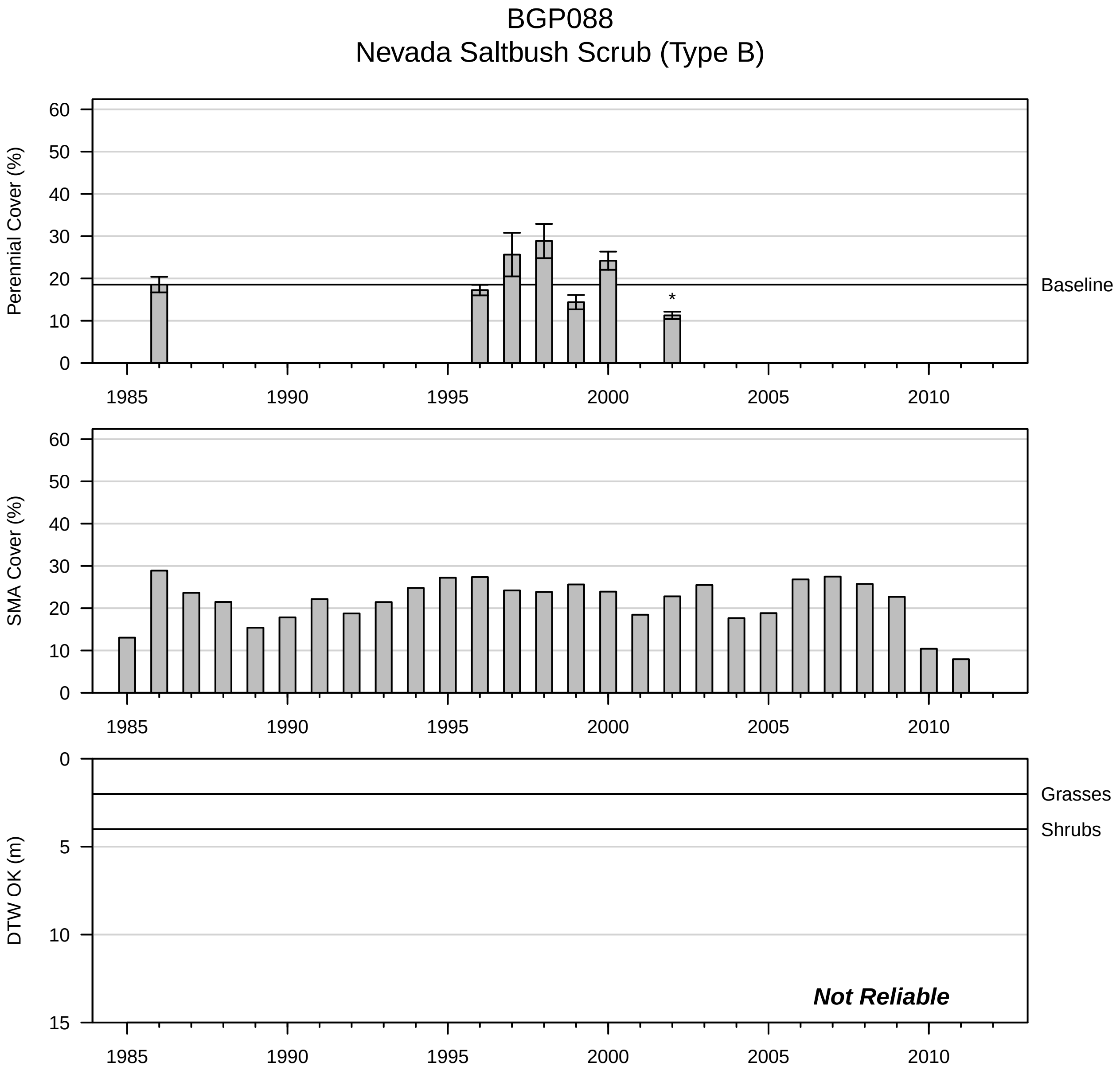


Figure 6: 2002 Wellfield

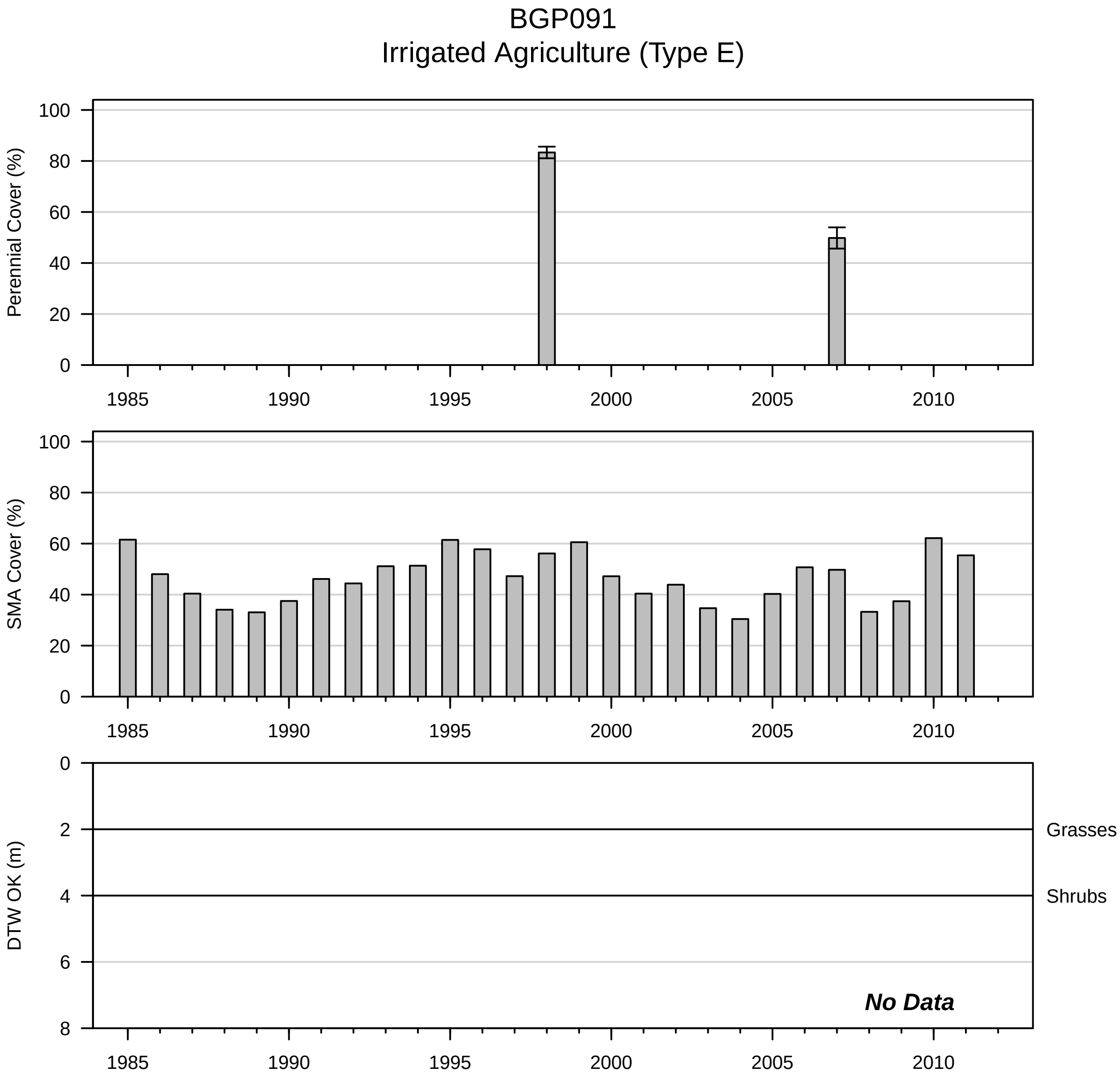


Figure 7: 2007 Wellfield

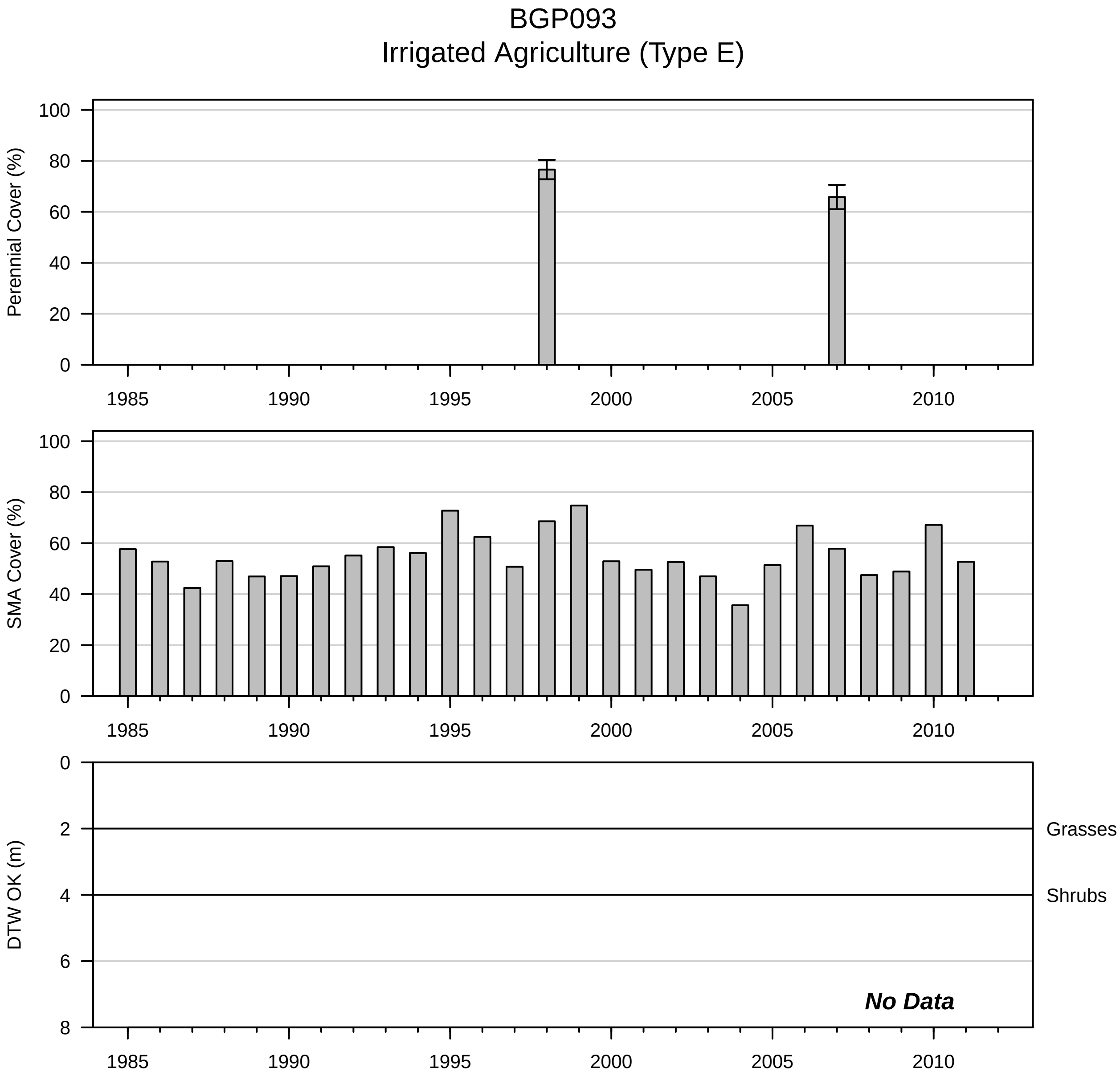


Figure 8: 2007 Wellfield

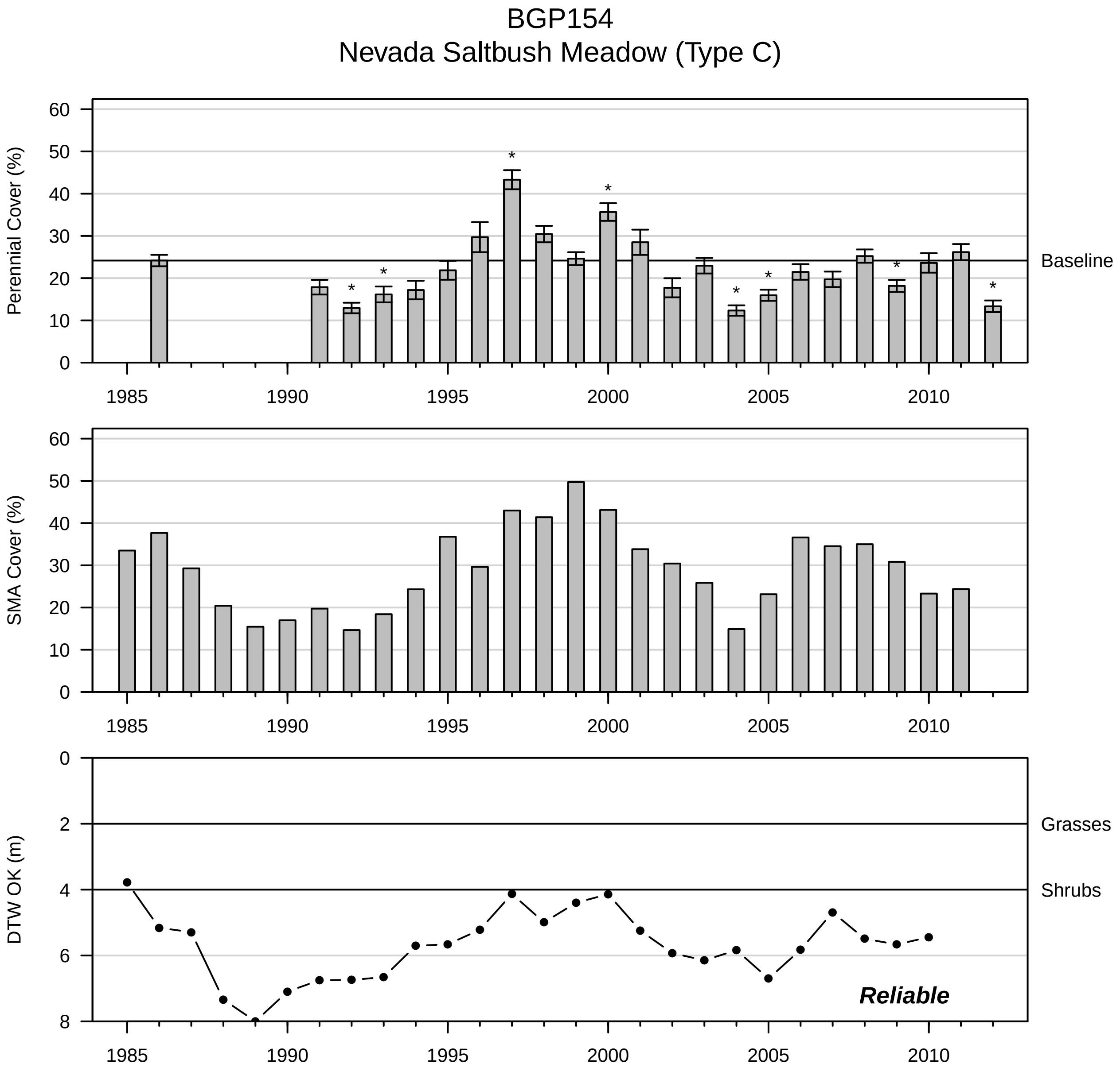


Figure 9: 2012 Wellfield

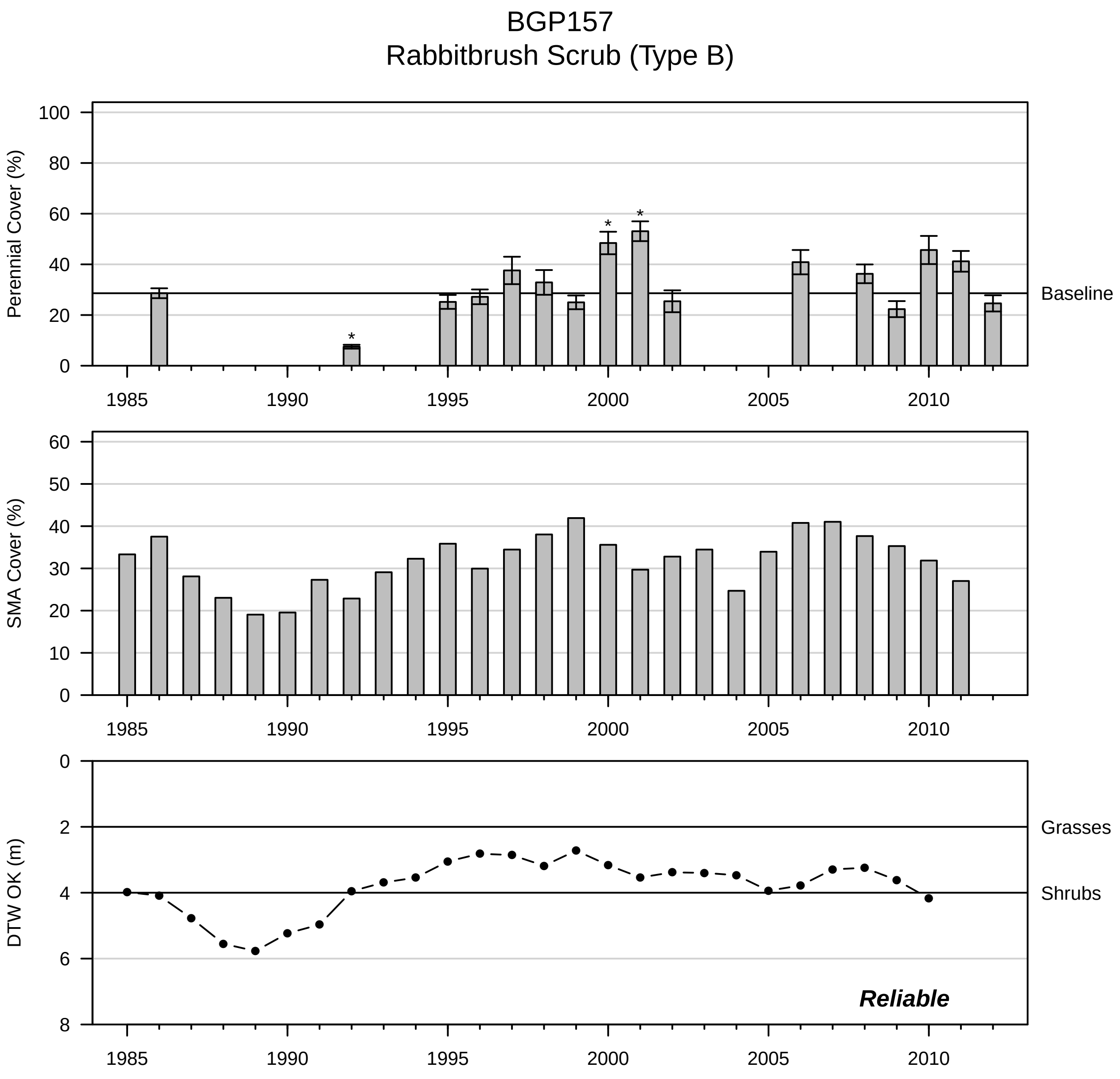


Figure 10: 2012 Wellfield

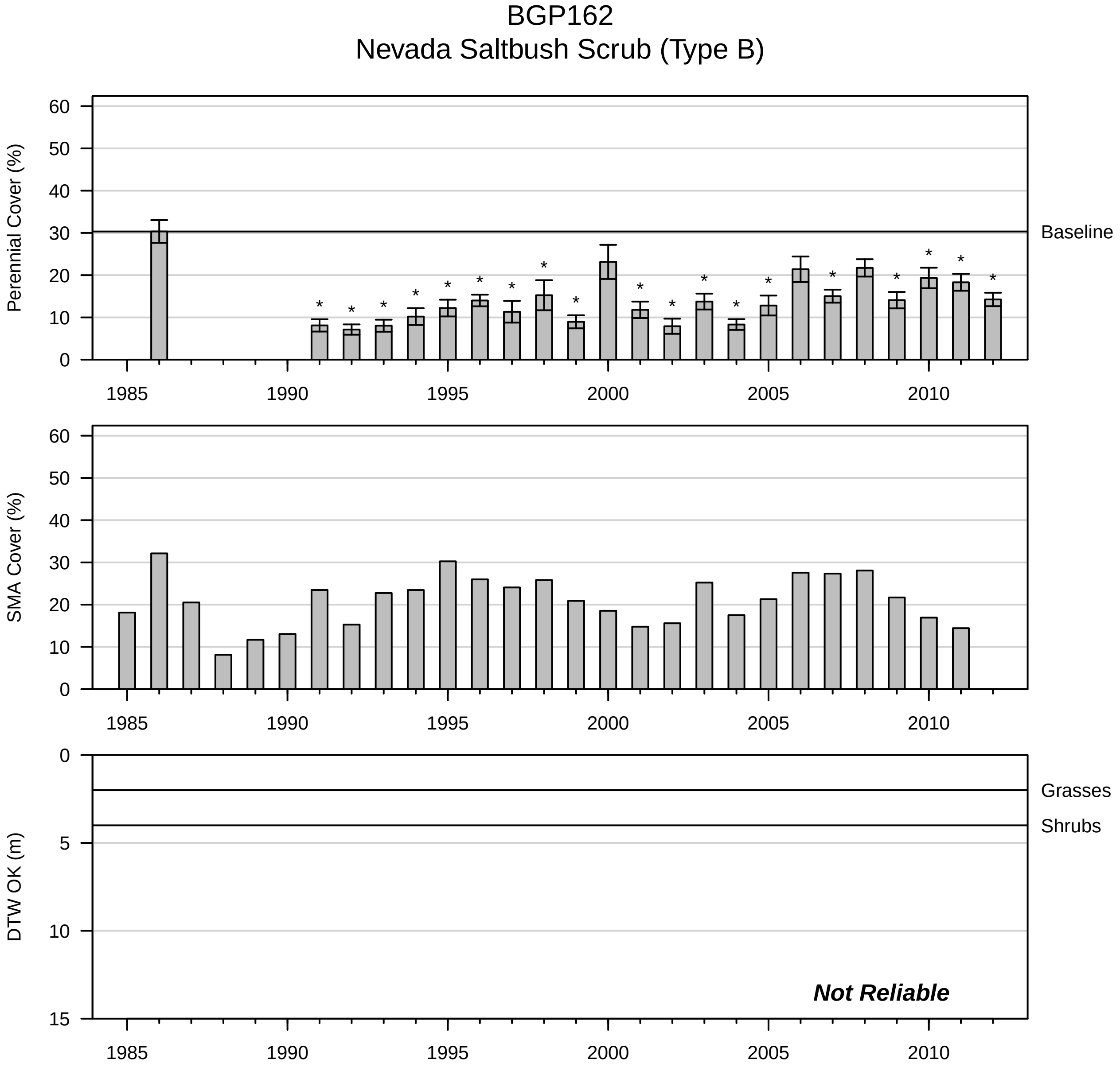


Figure 11: 2012 Wellfield

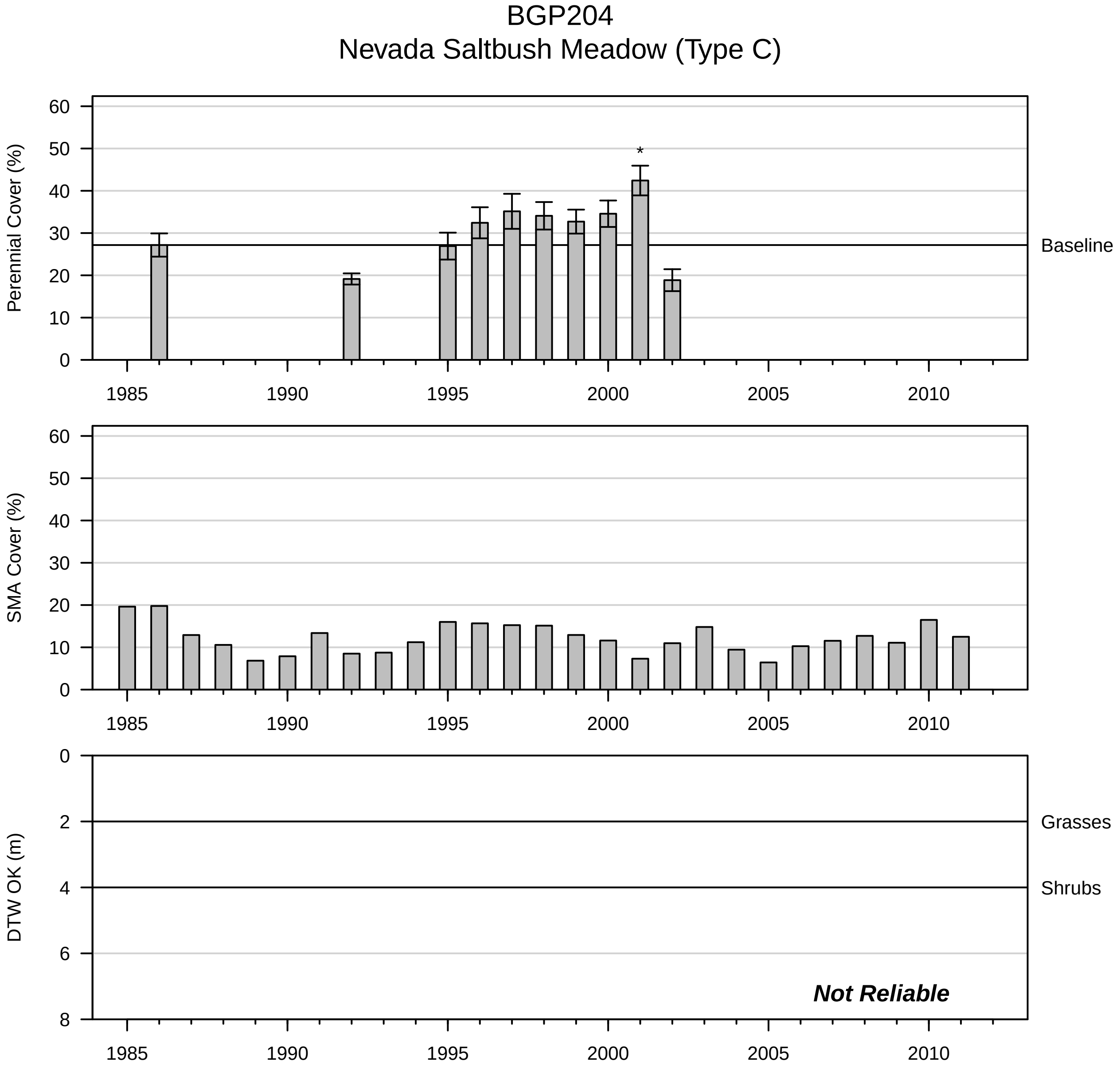


Figure 12: 2002 Control

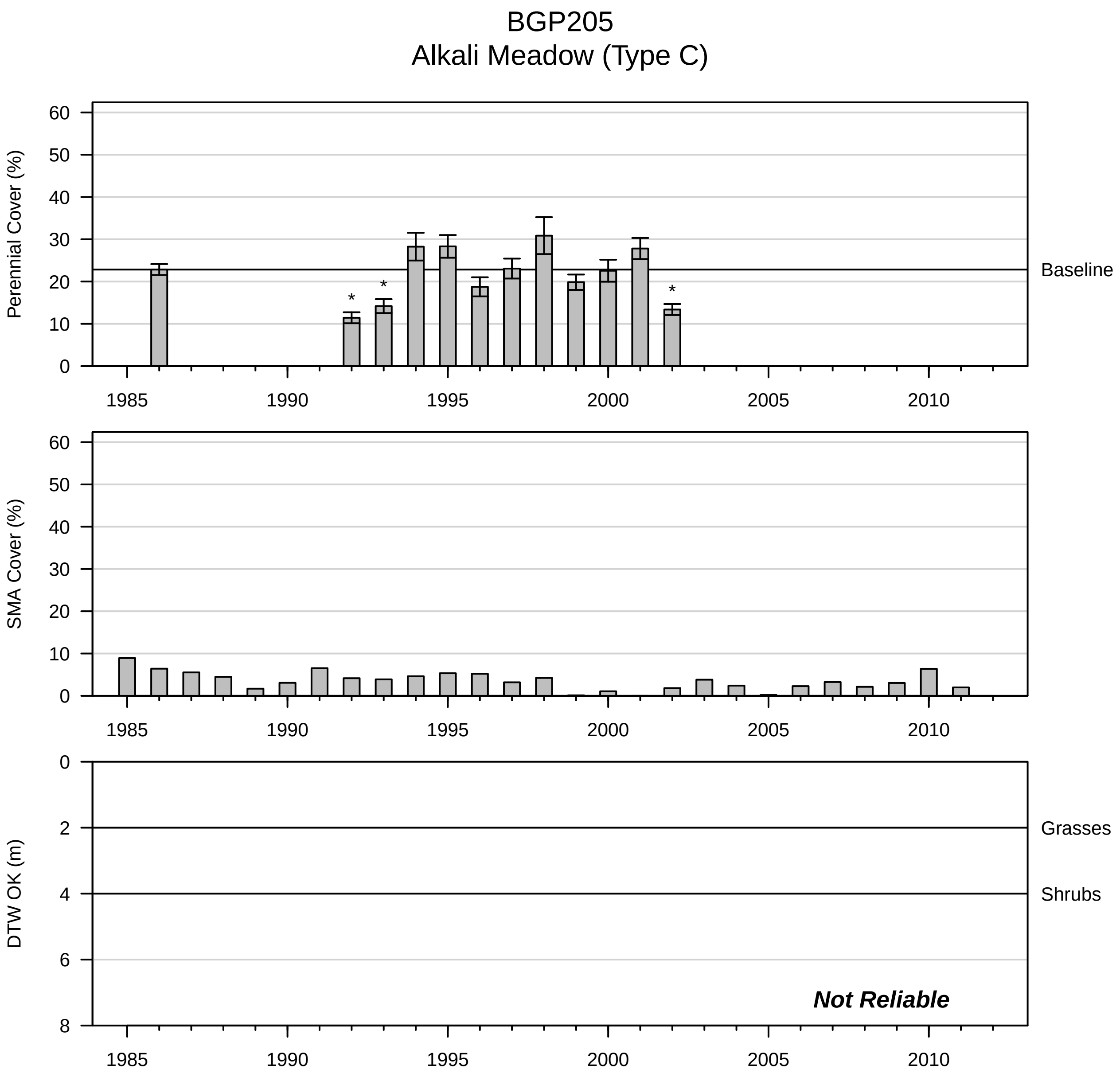


Figure 13: 2002 Control

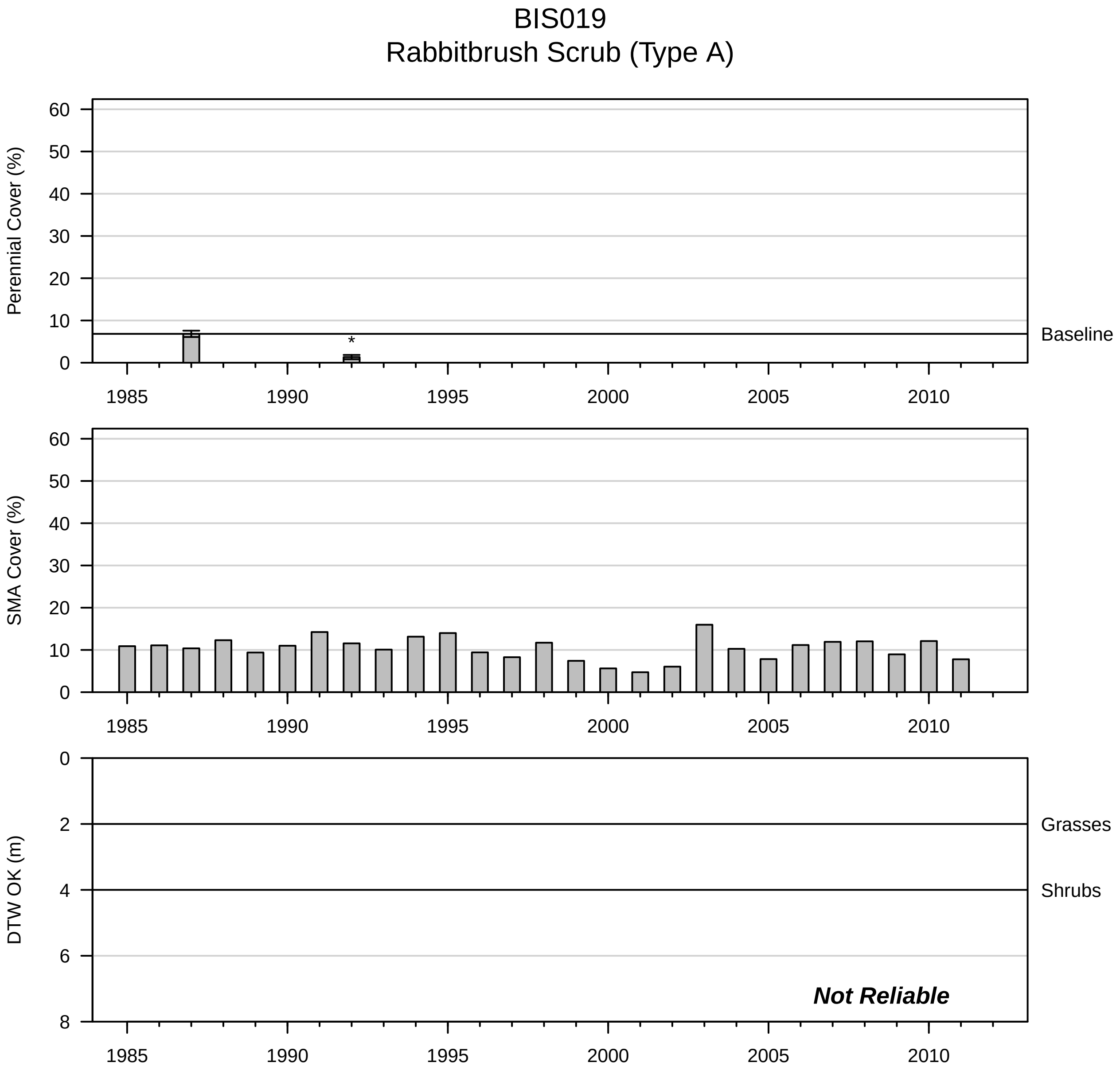


Figure 14: 1992 Control

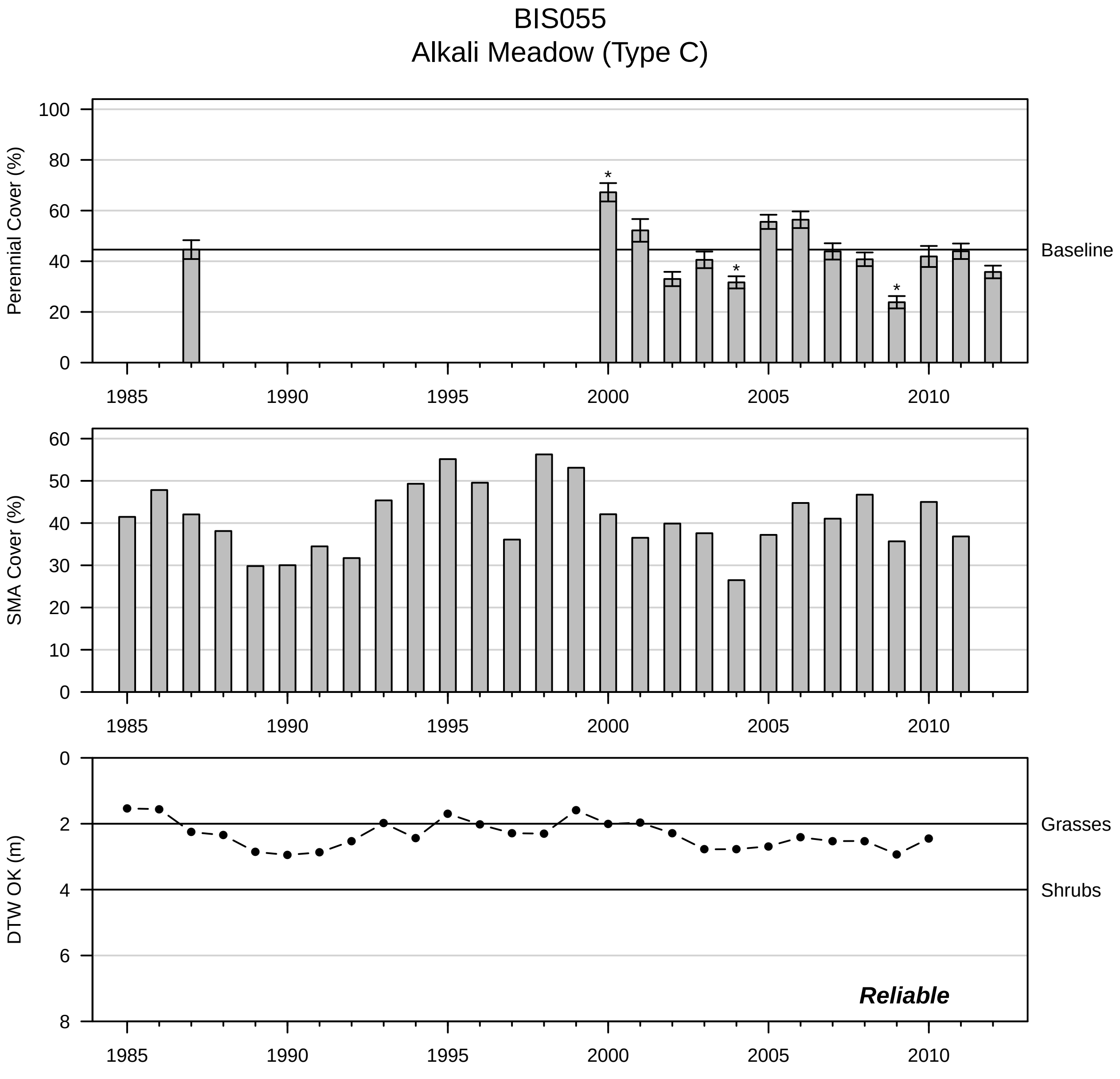


Figure 15: 2012 Control

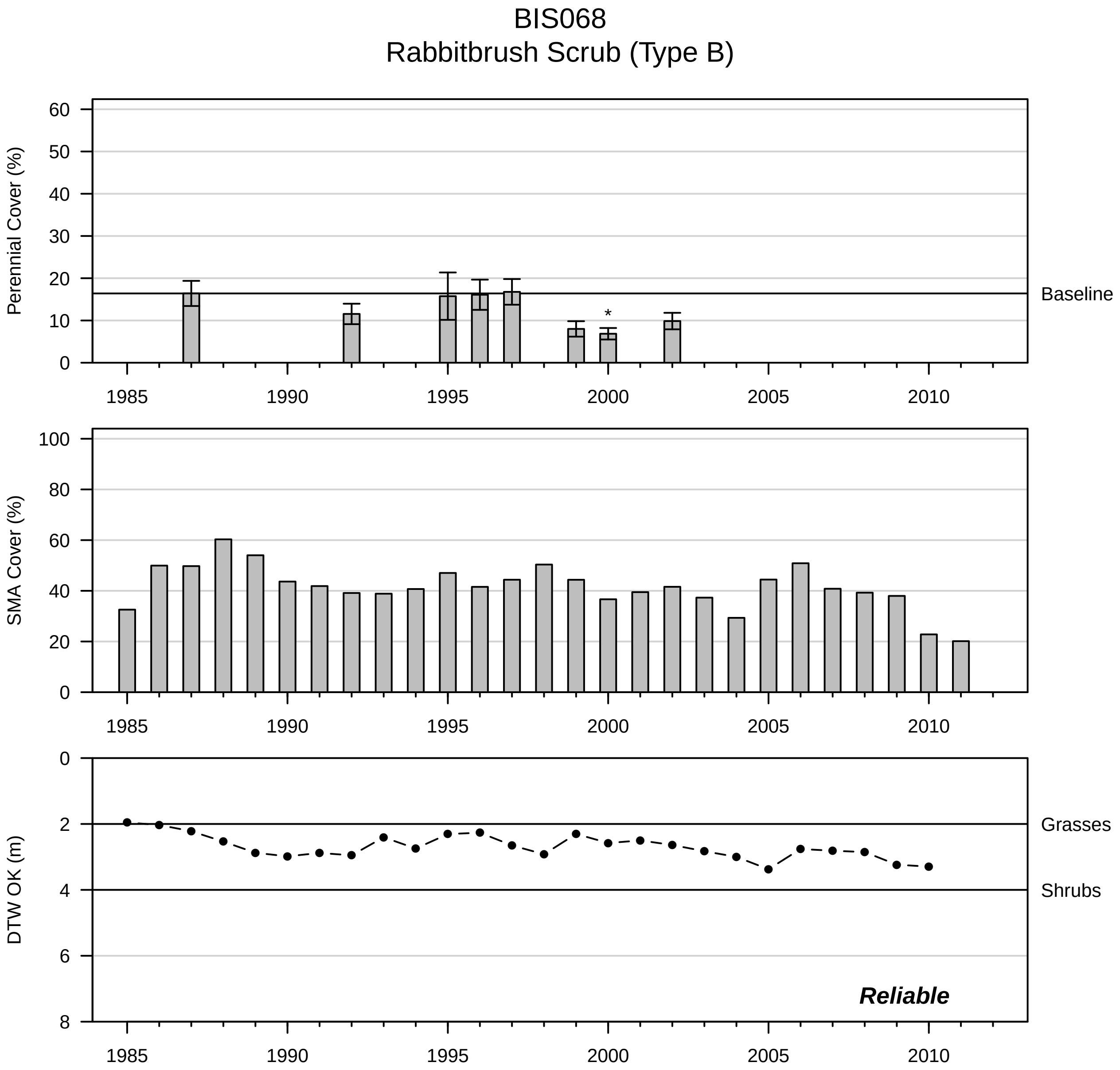


Figure 16: 2002 Control

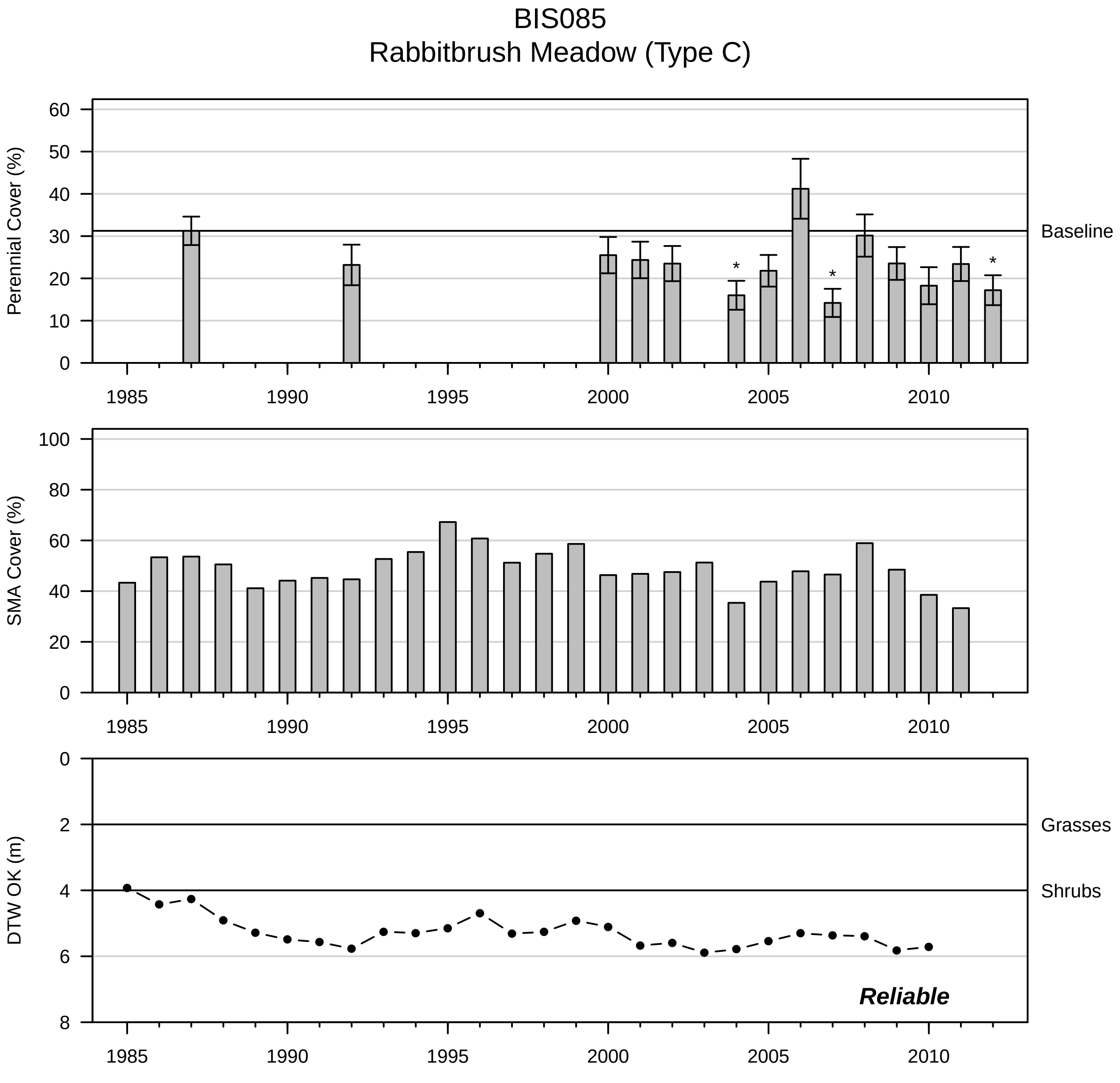


Figure 17: 2012 Wellfield

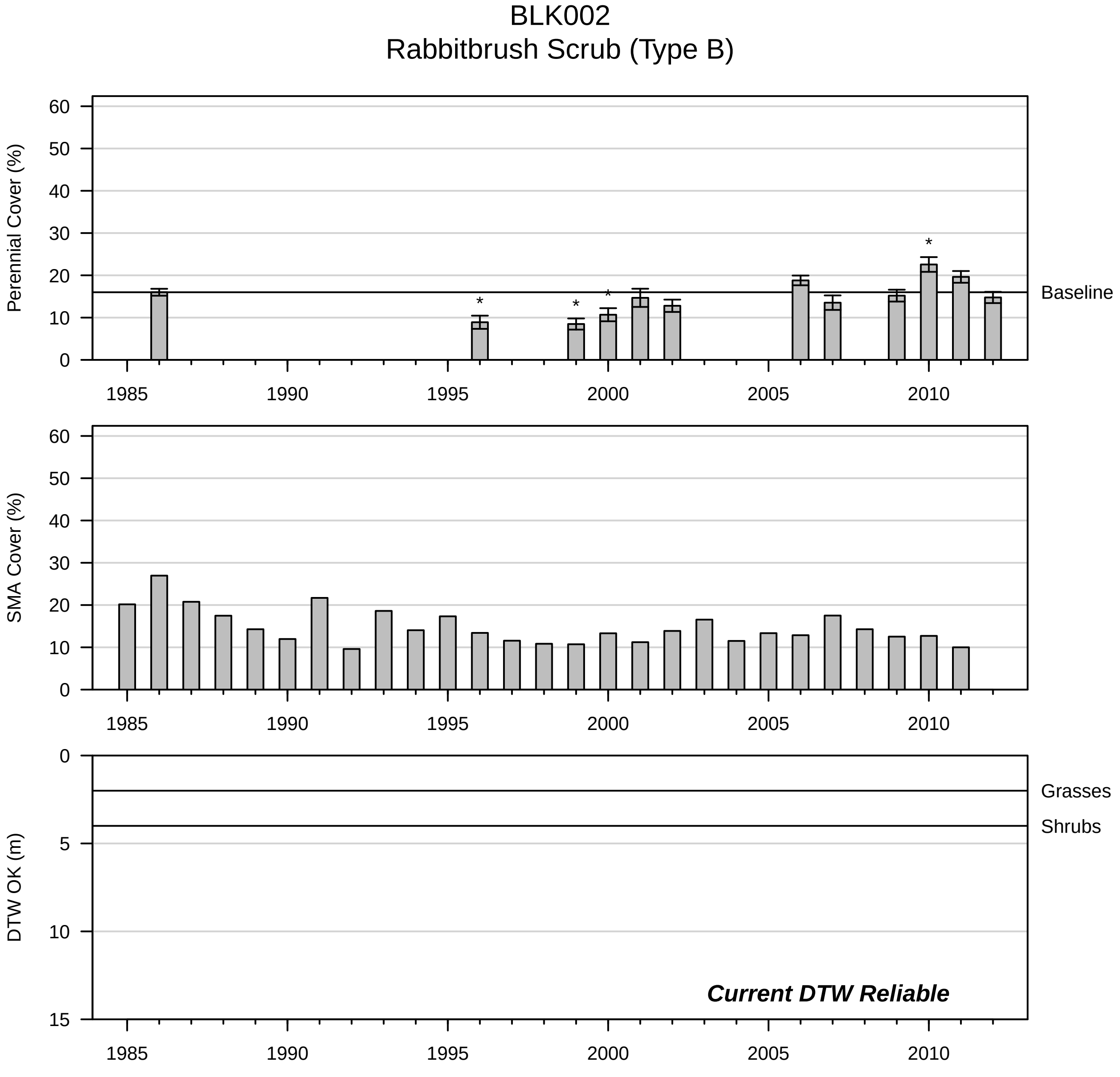


Figure 18: 2012 Wellfield

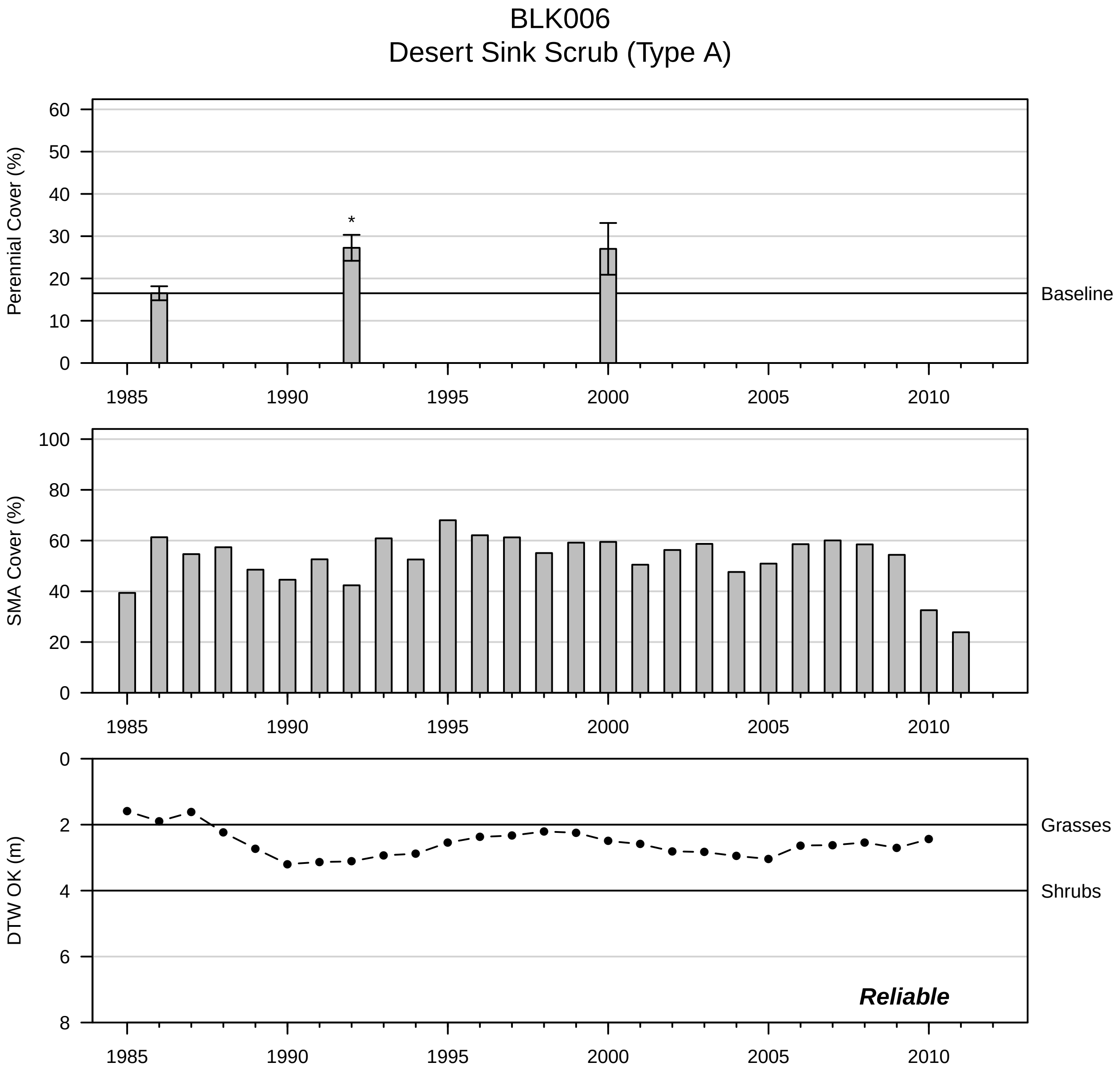


Figure 19: 2000 Wellfield

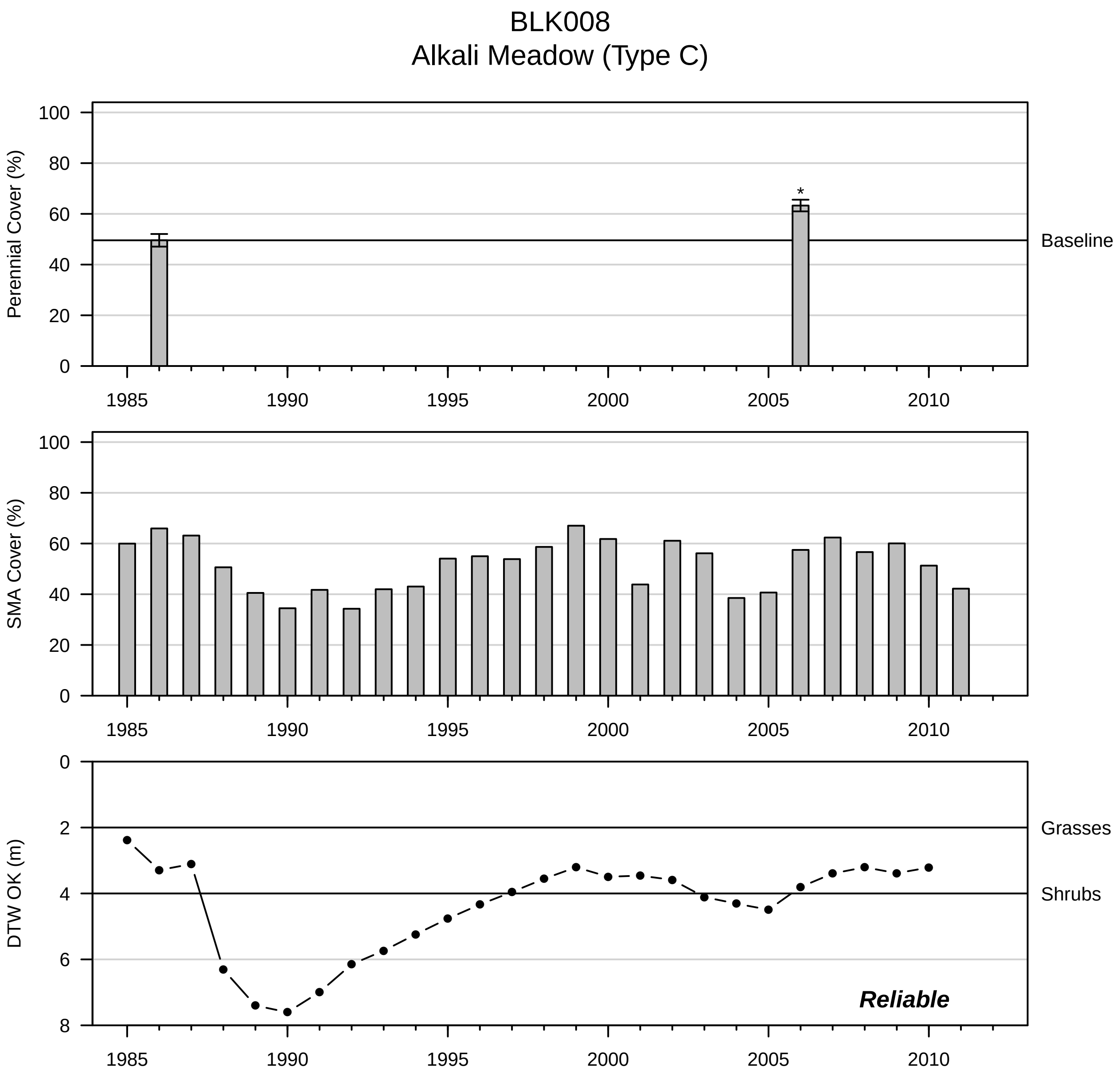


Figure 20: 2006 Wellfield

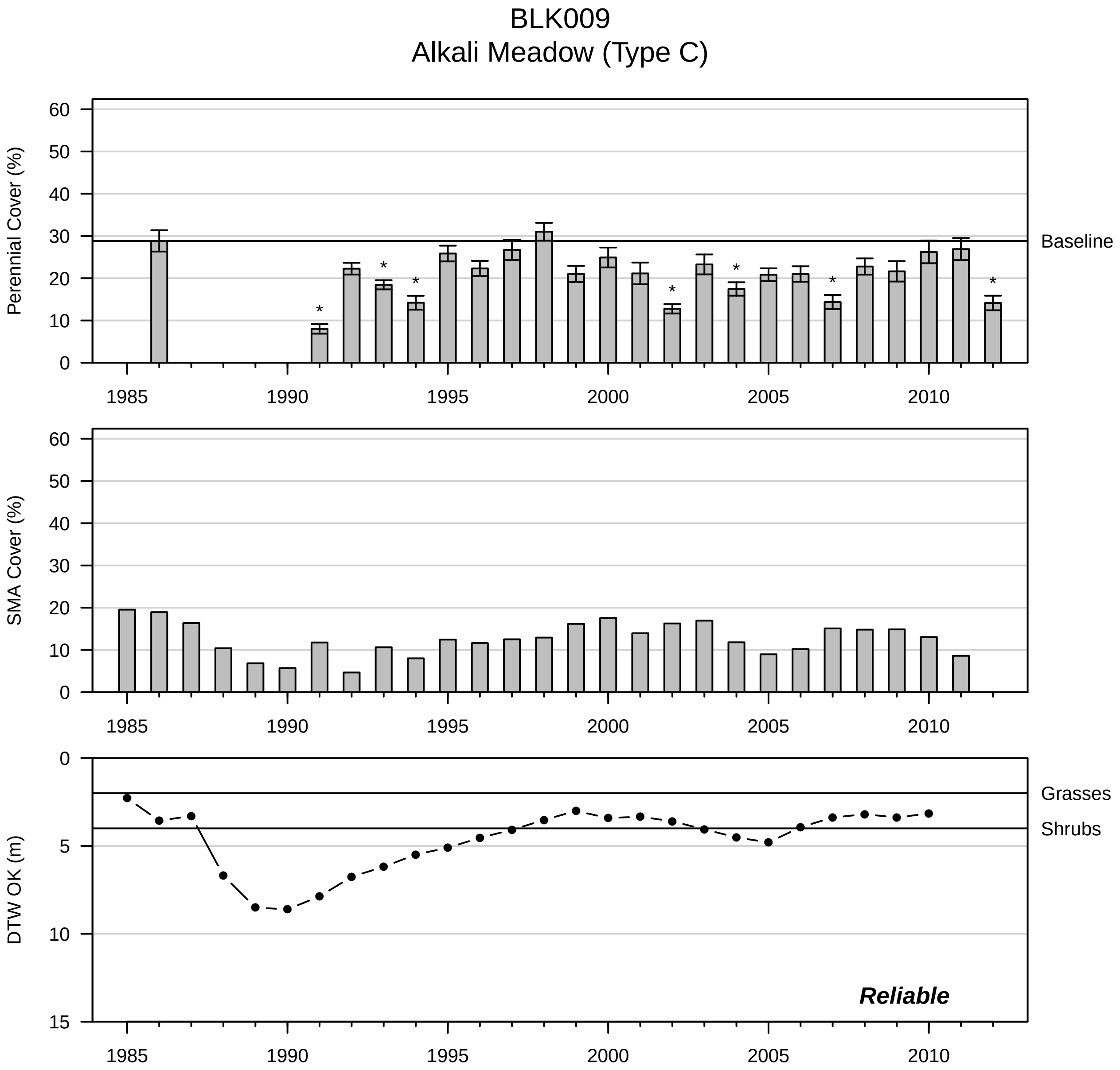


Figure 21: 2012 Wellfield

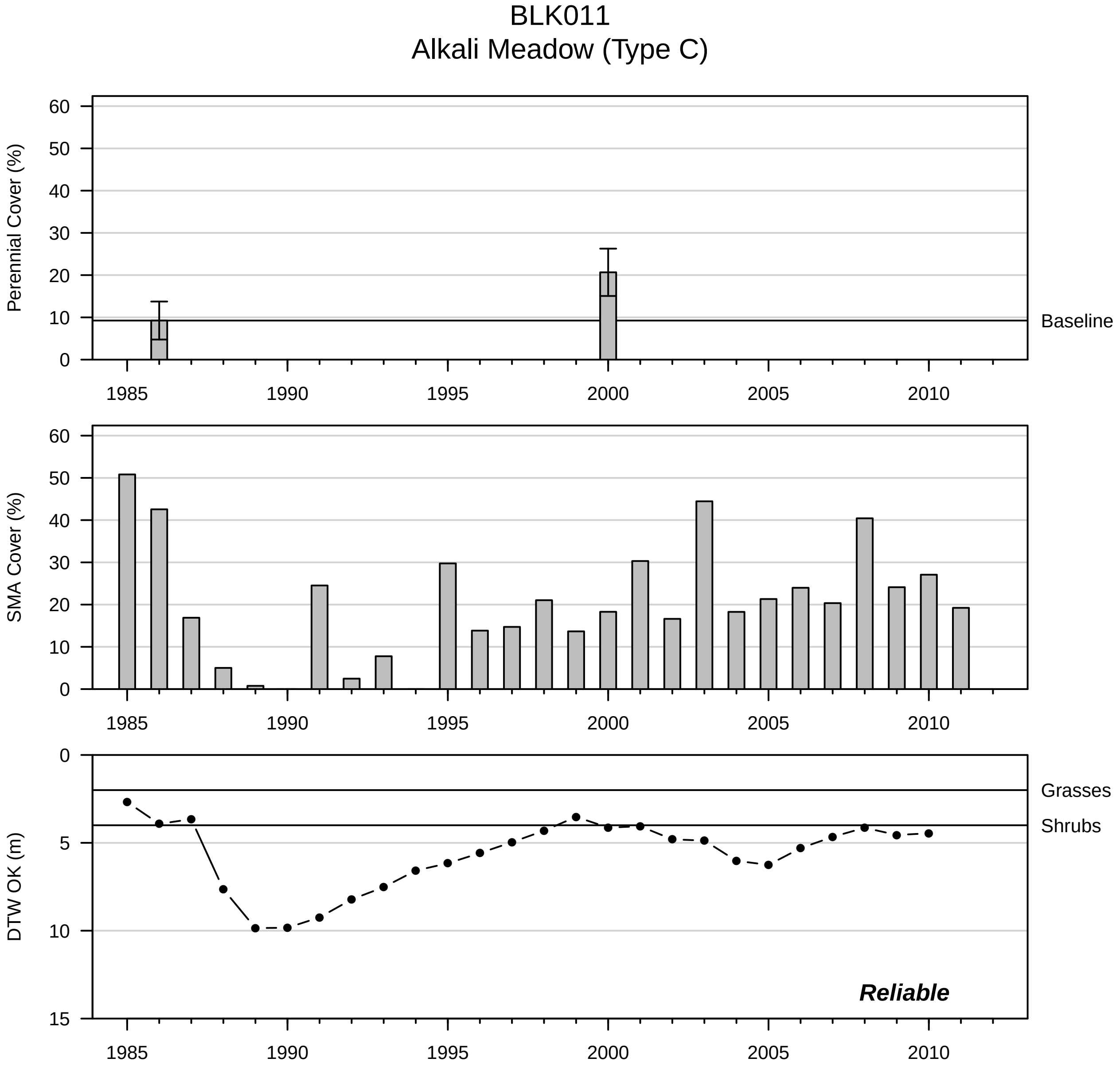


Figure 22: 2000 Wellfield

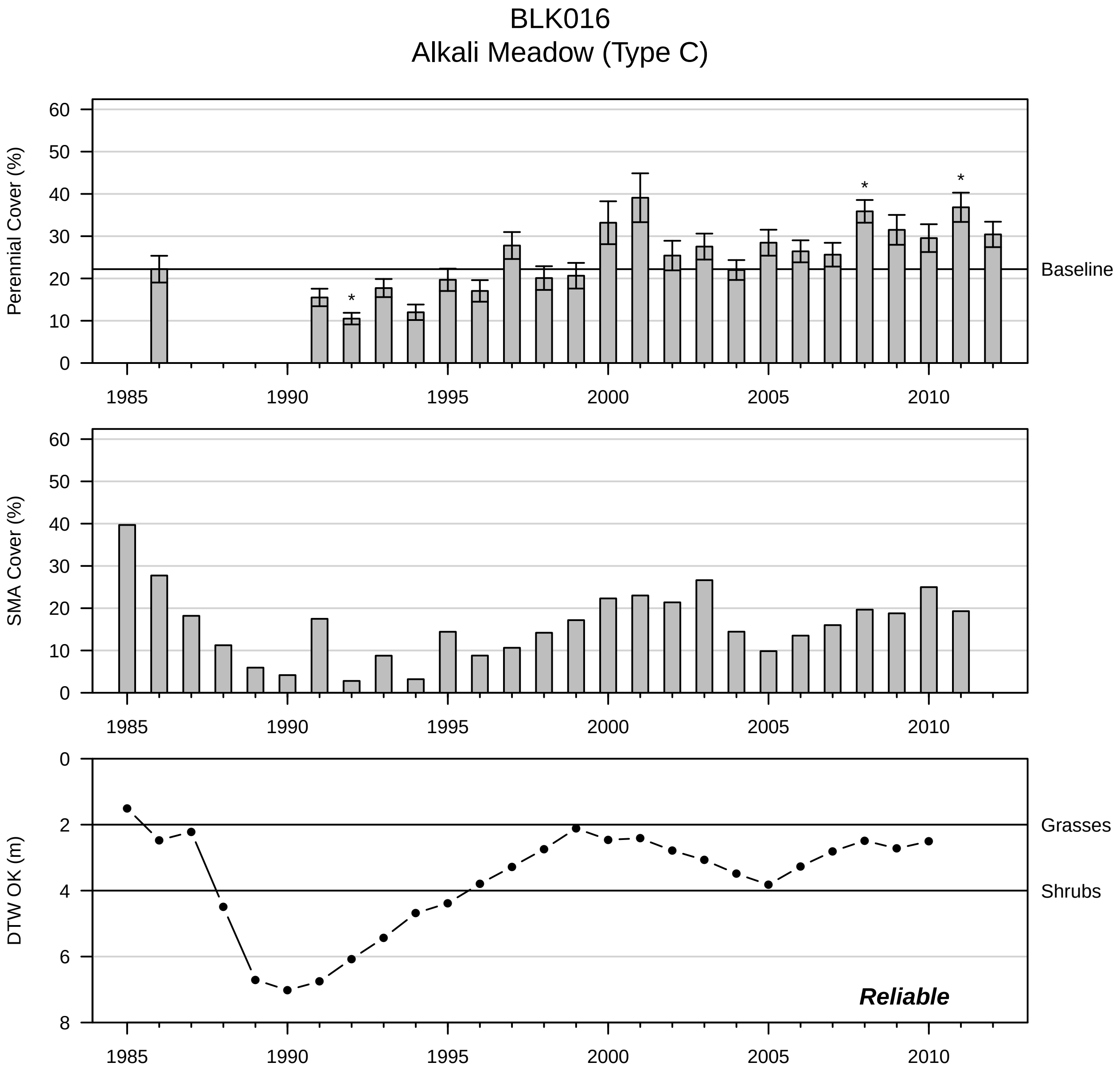
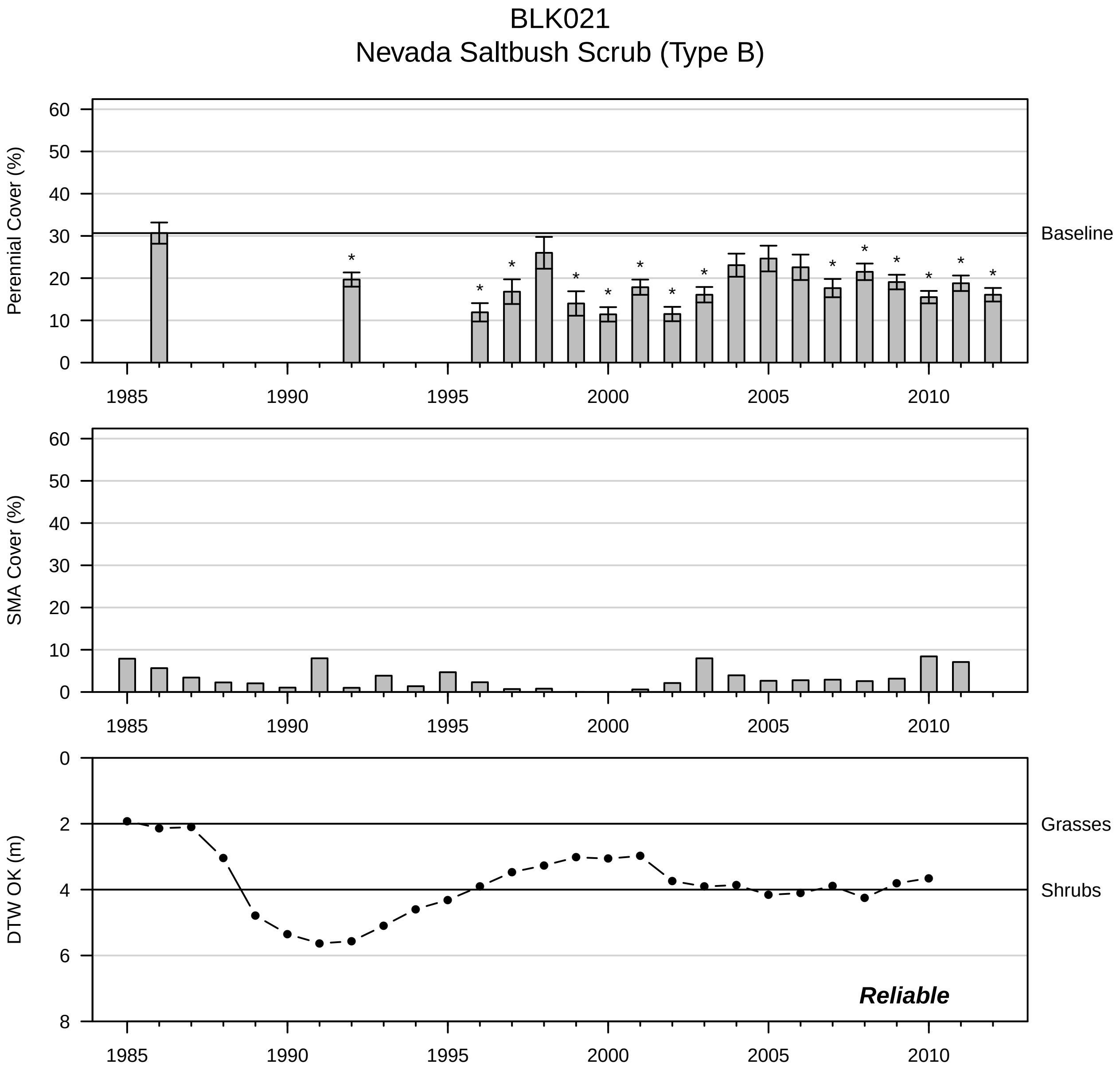


Figure 23: 2012 Wellfield



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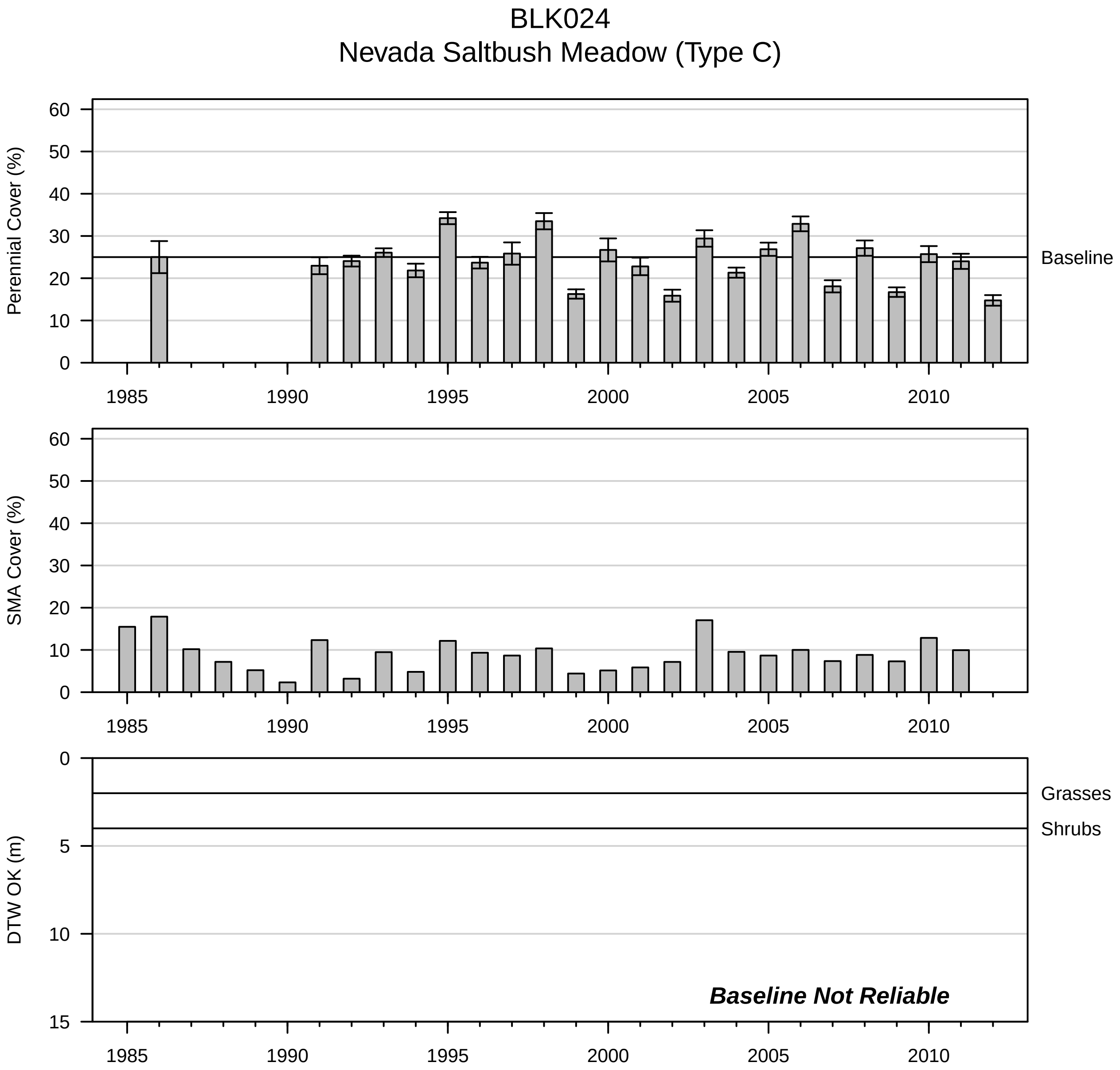


Figure 25: 2012 Wellfield

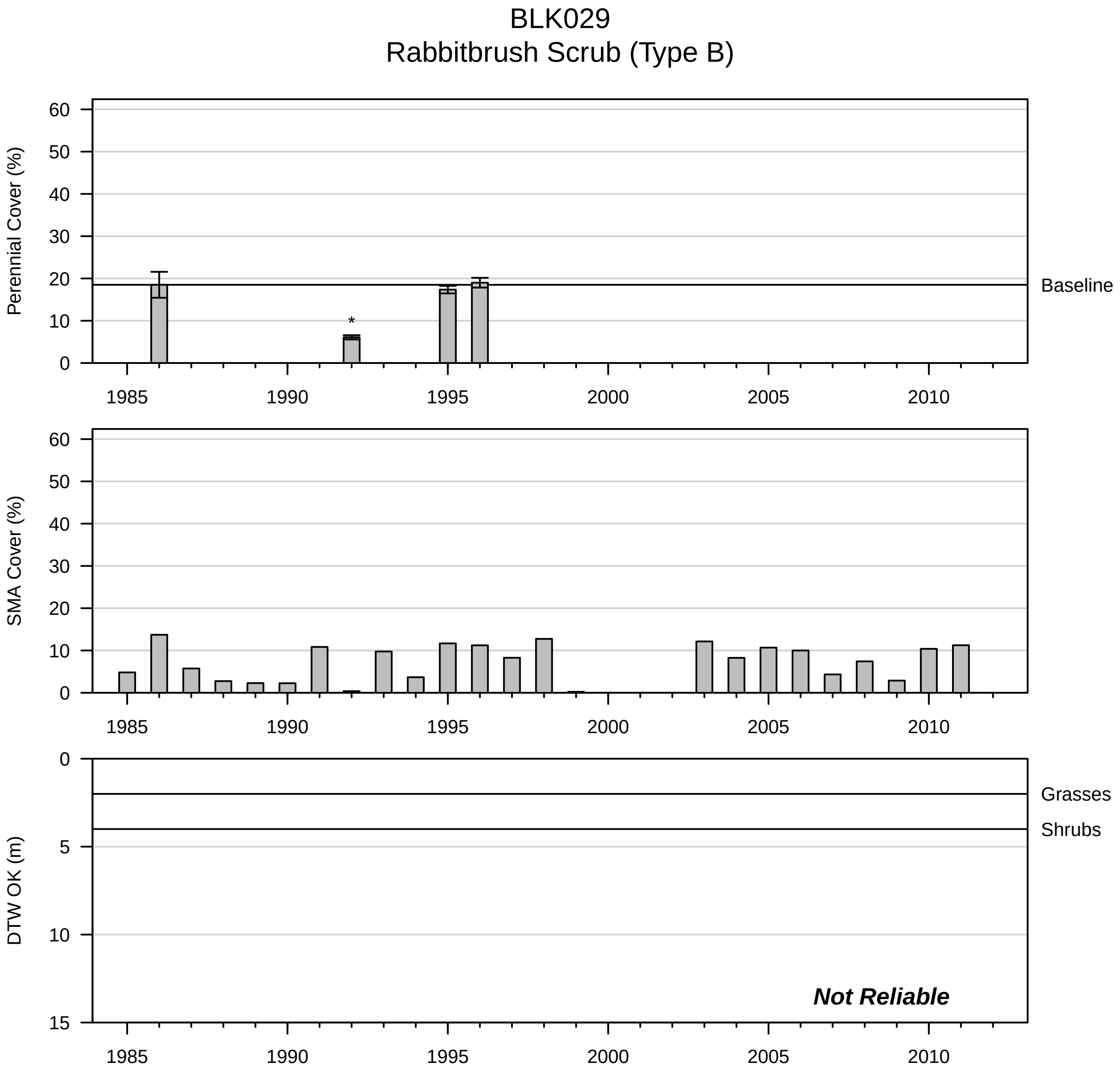


Figure 26: 1996 Control

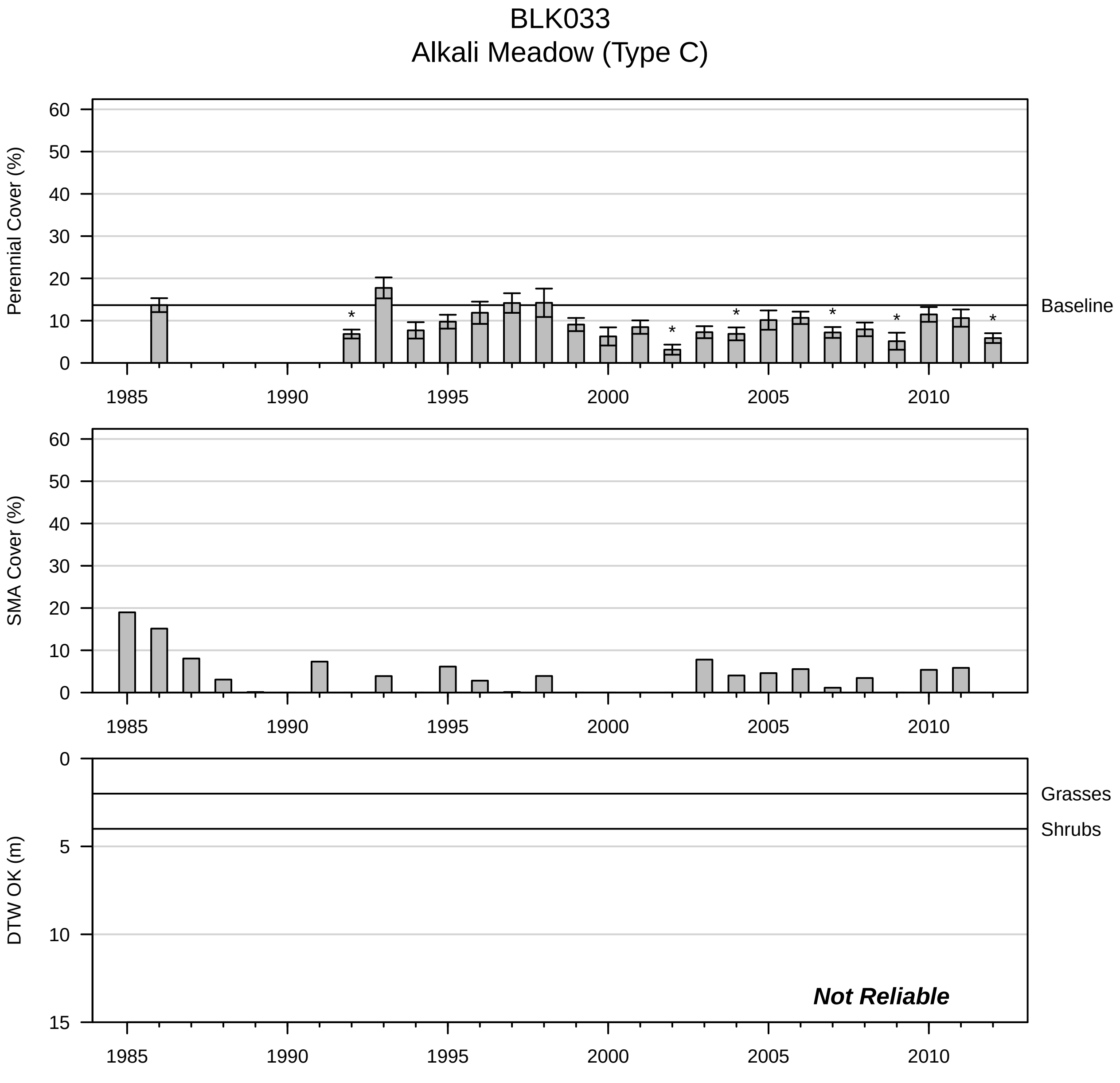


Figure 27: 2012 Wellfield

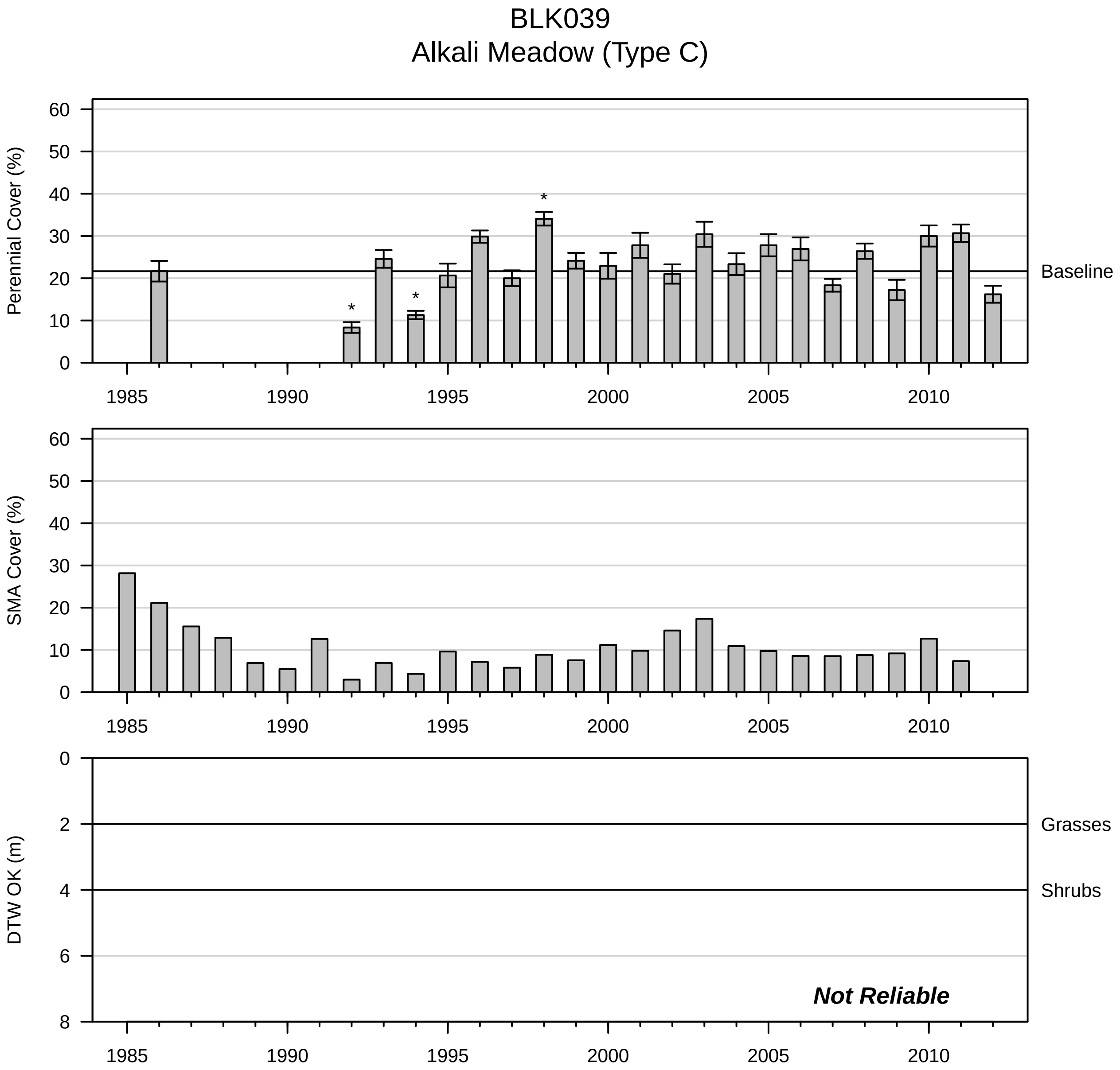


Figure 28: 2012 Wellfield

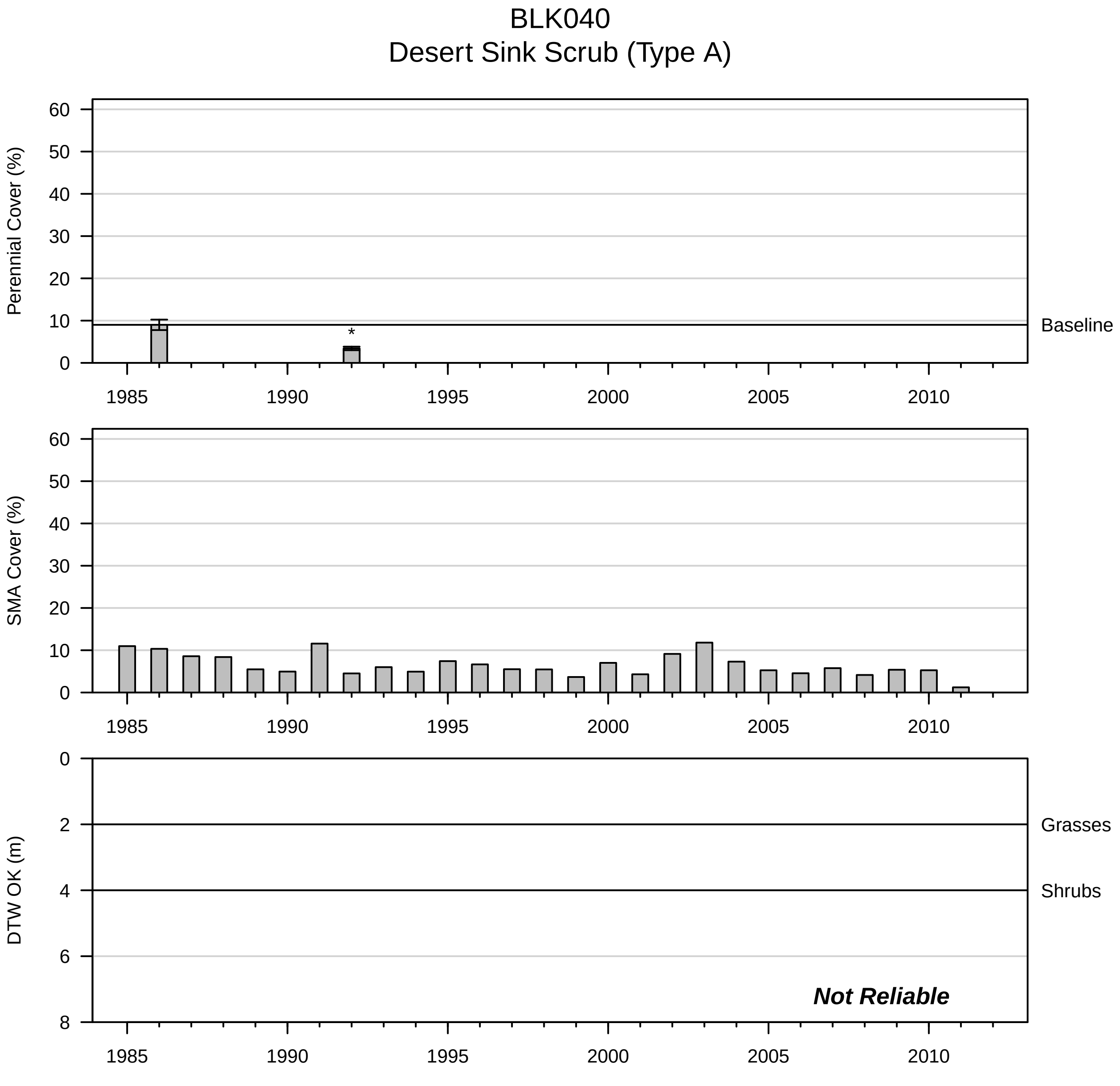
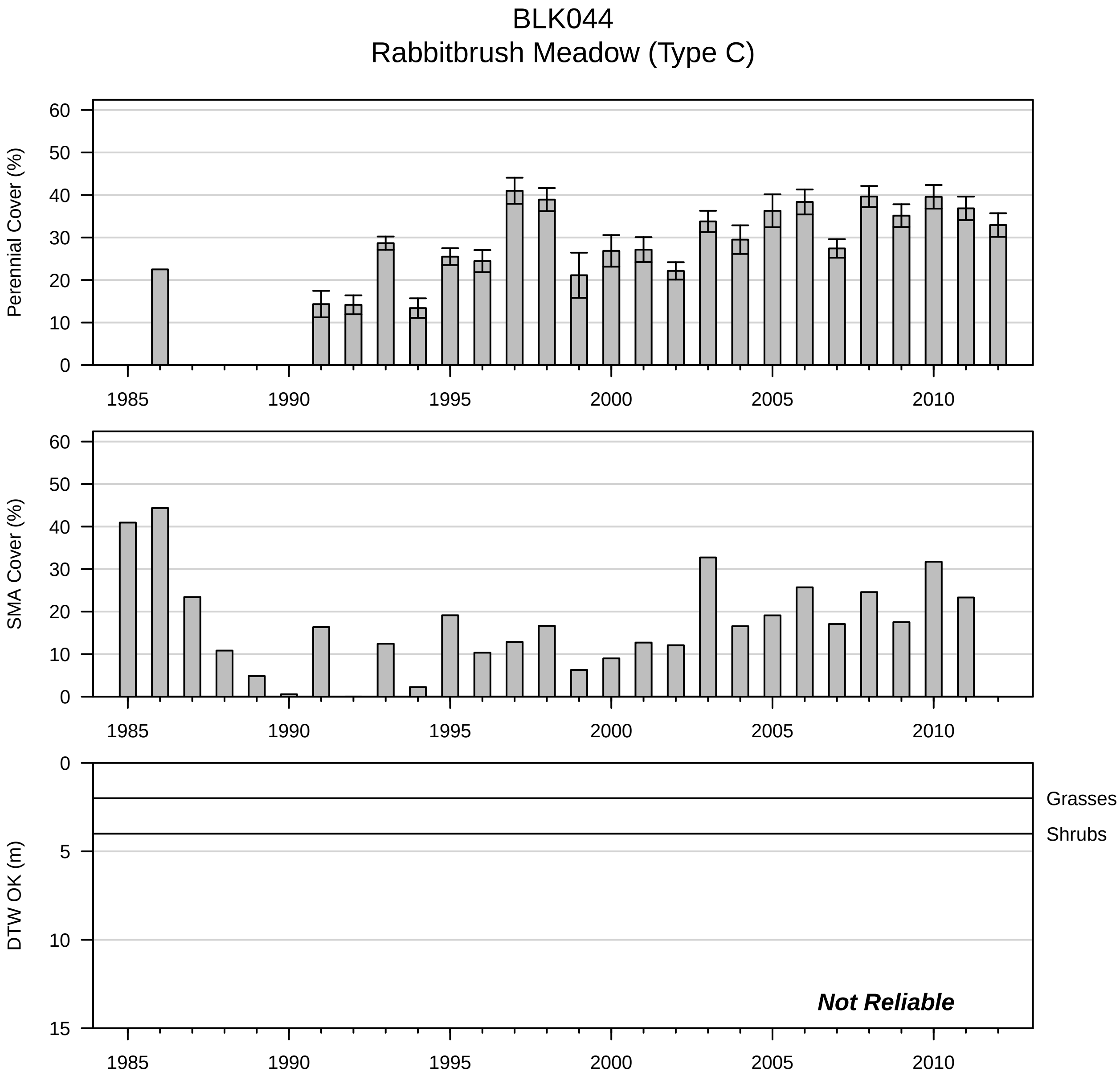


Figure 29: 1992 Wellfield



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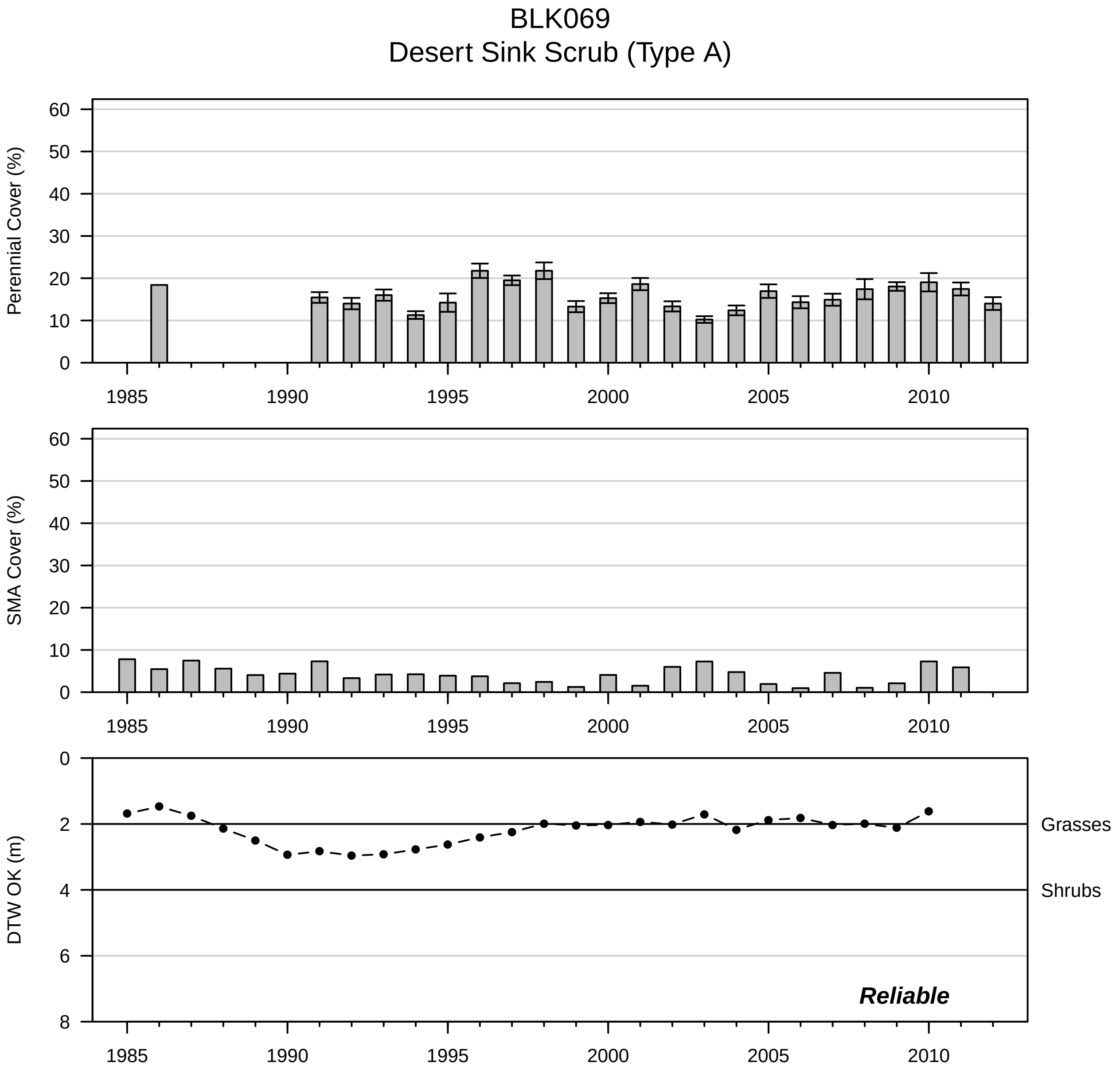

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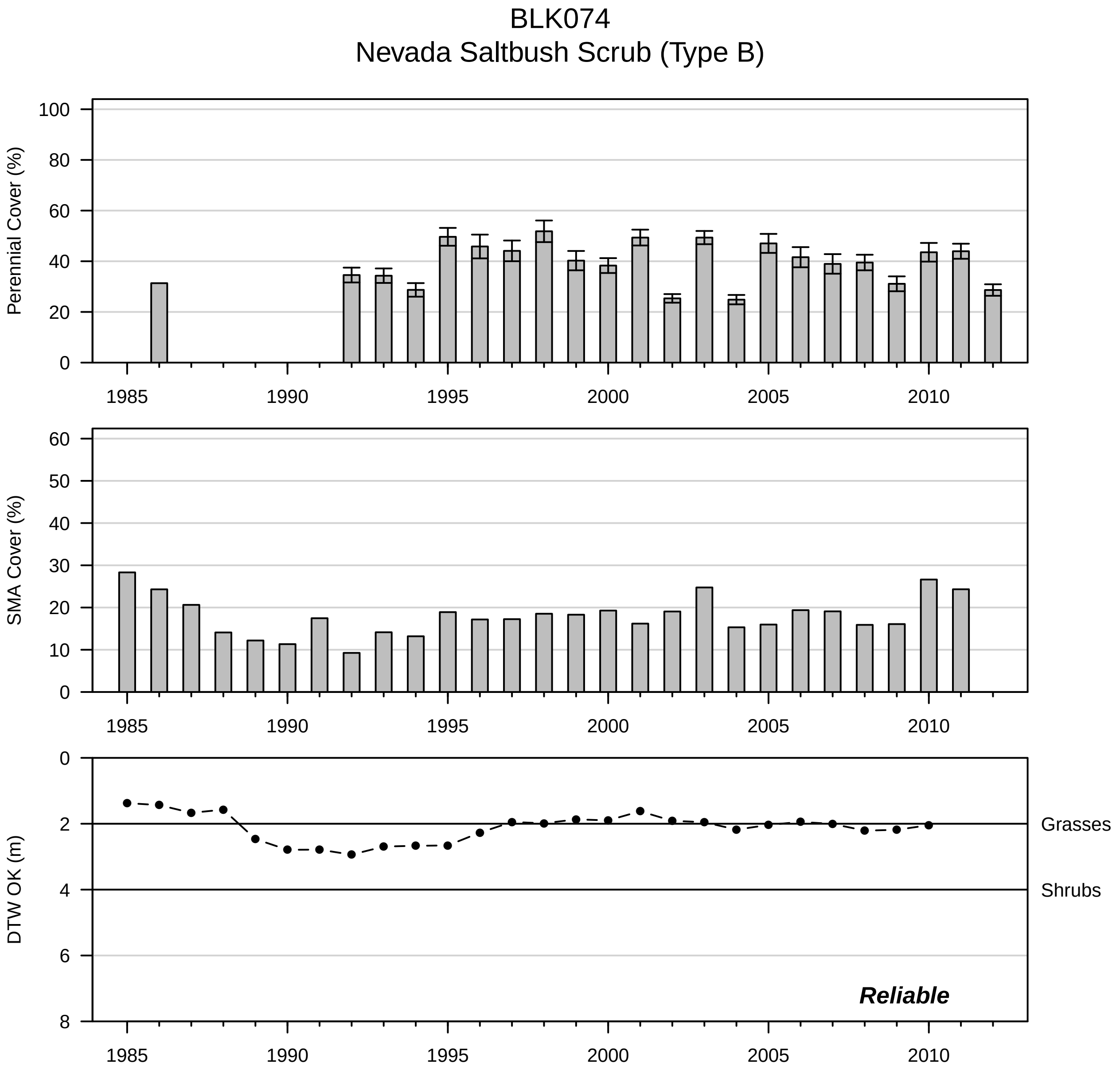

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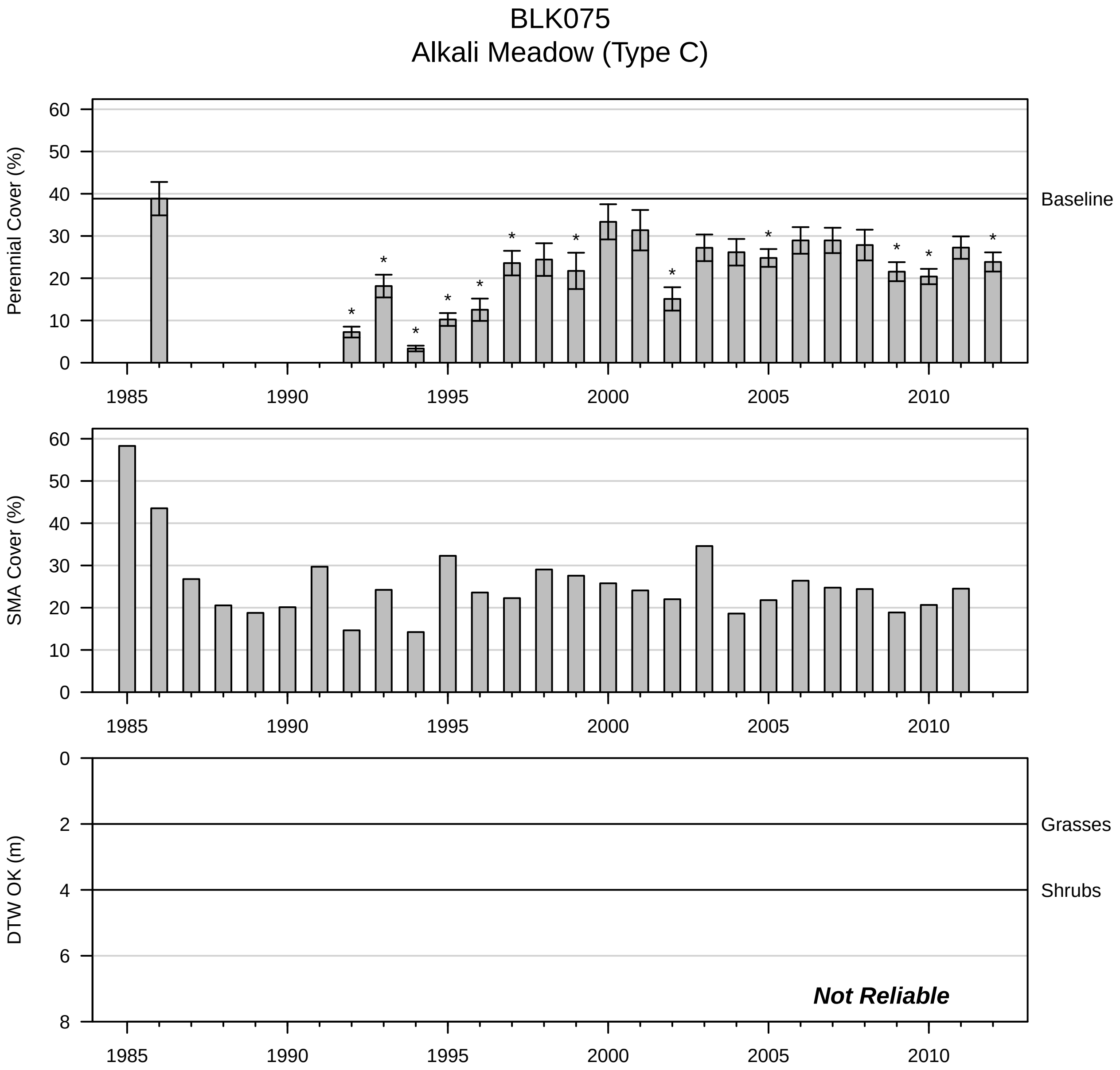

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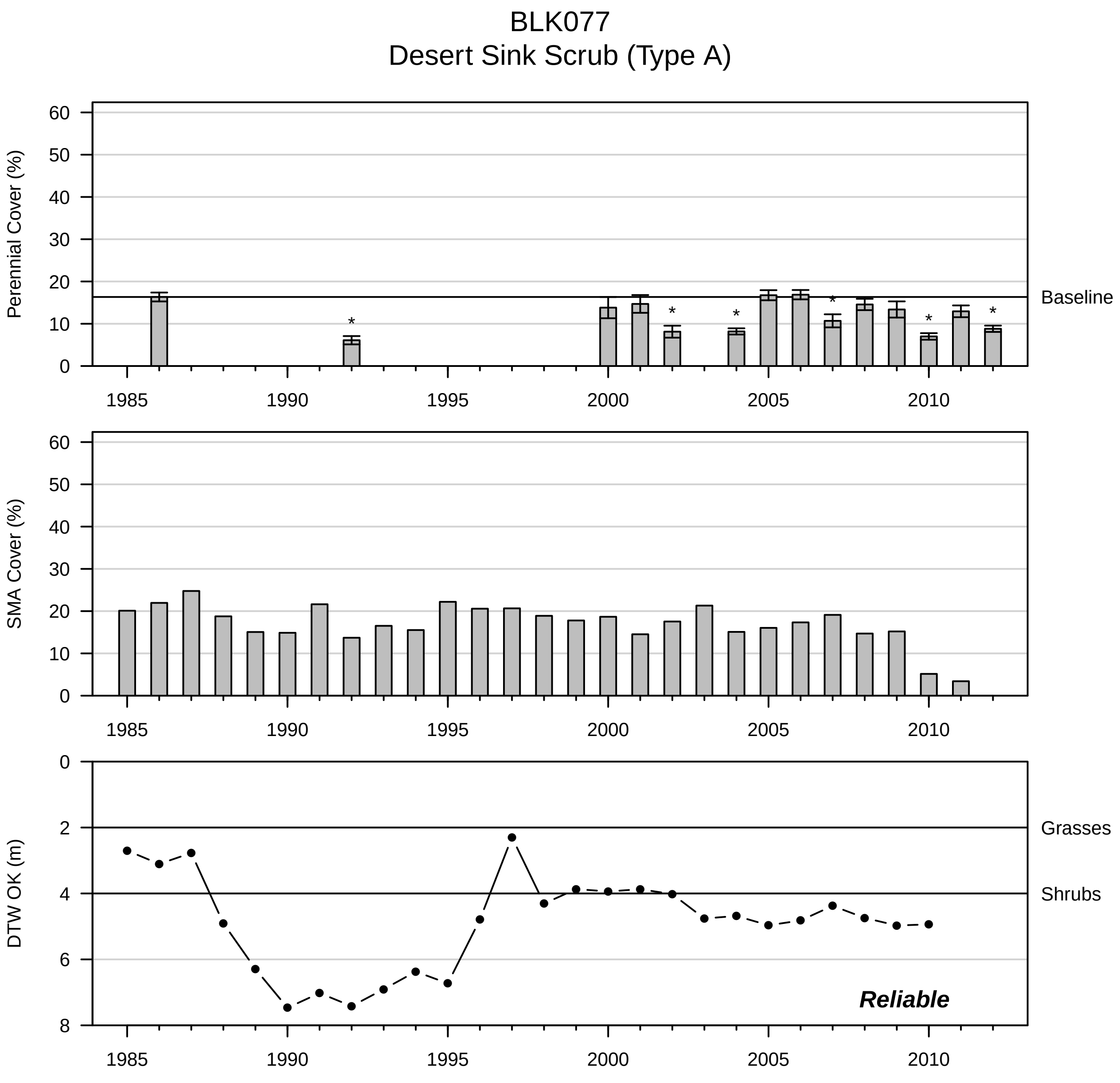

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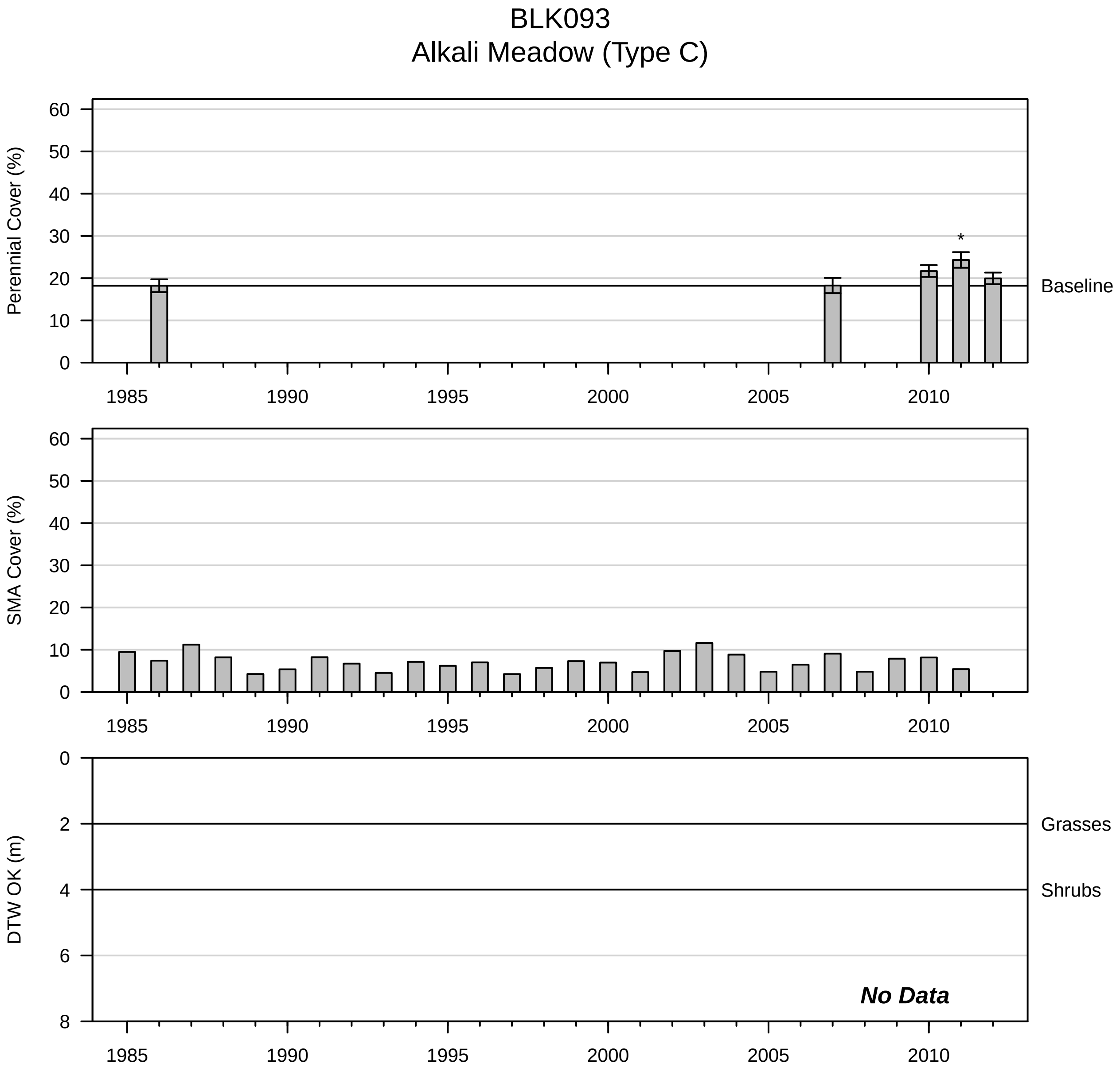

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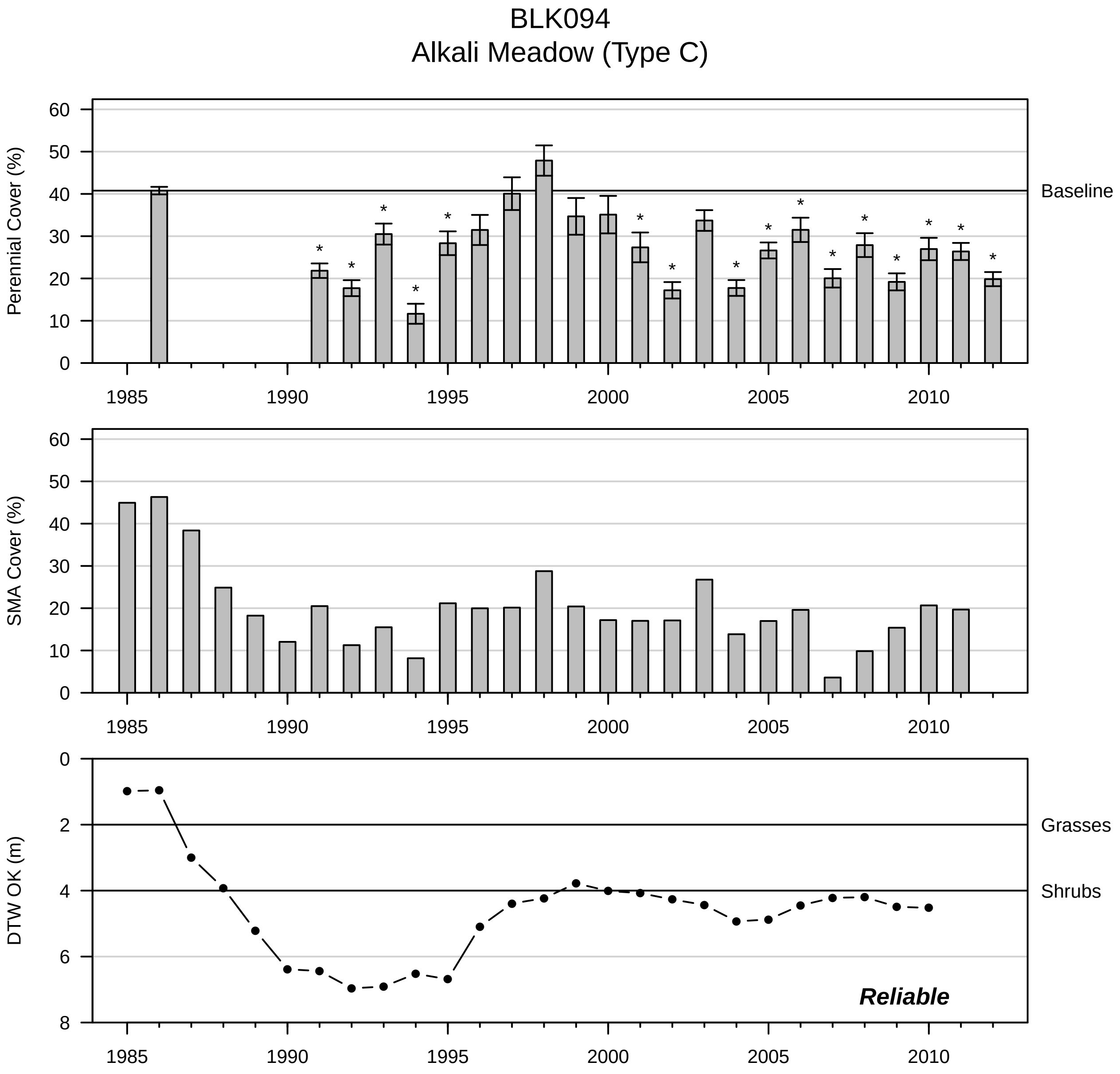

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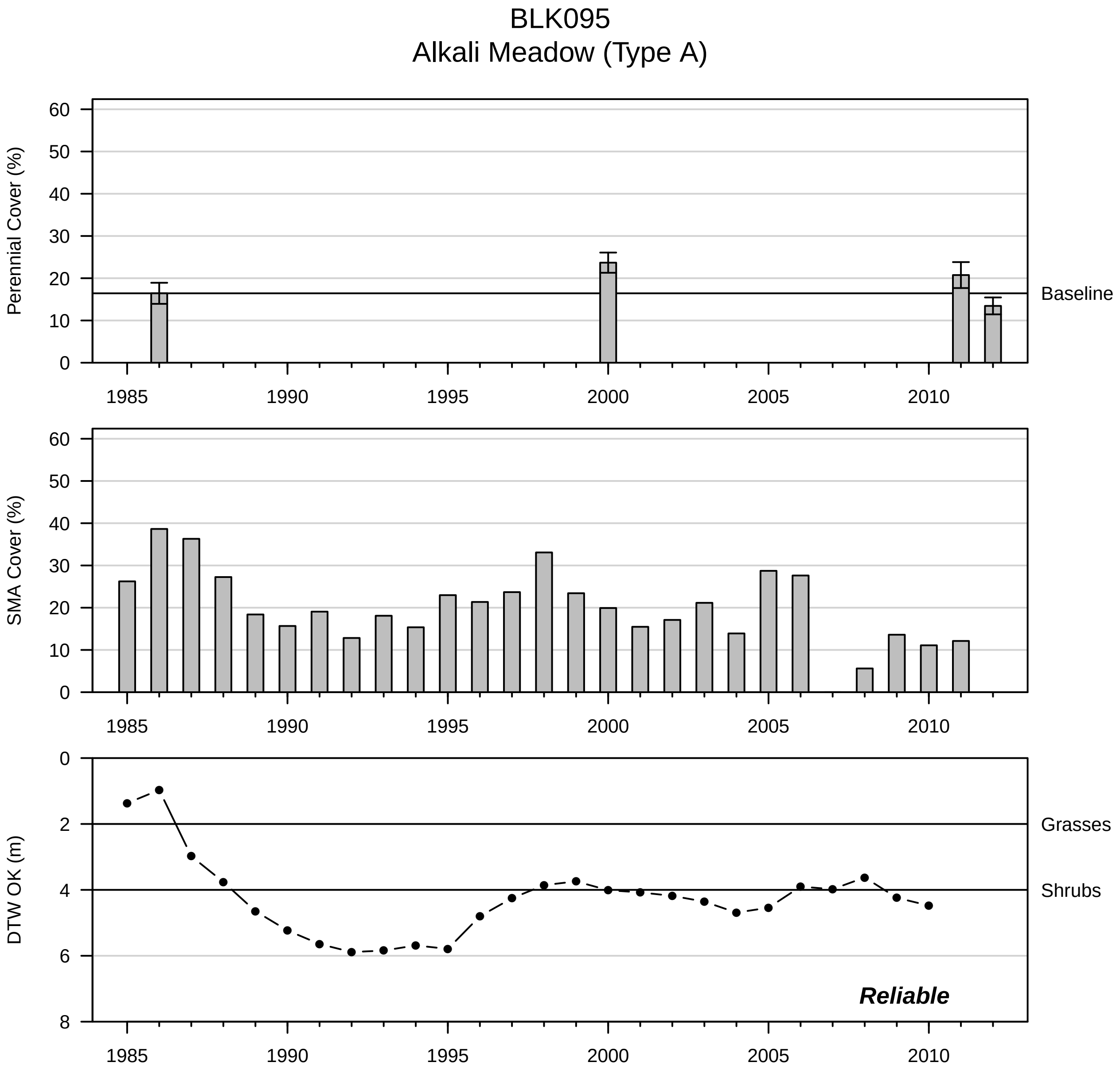

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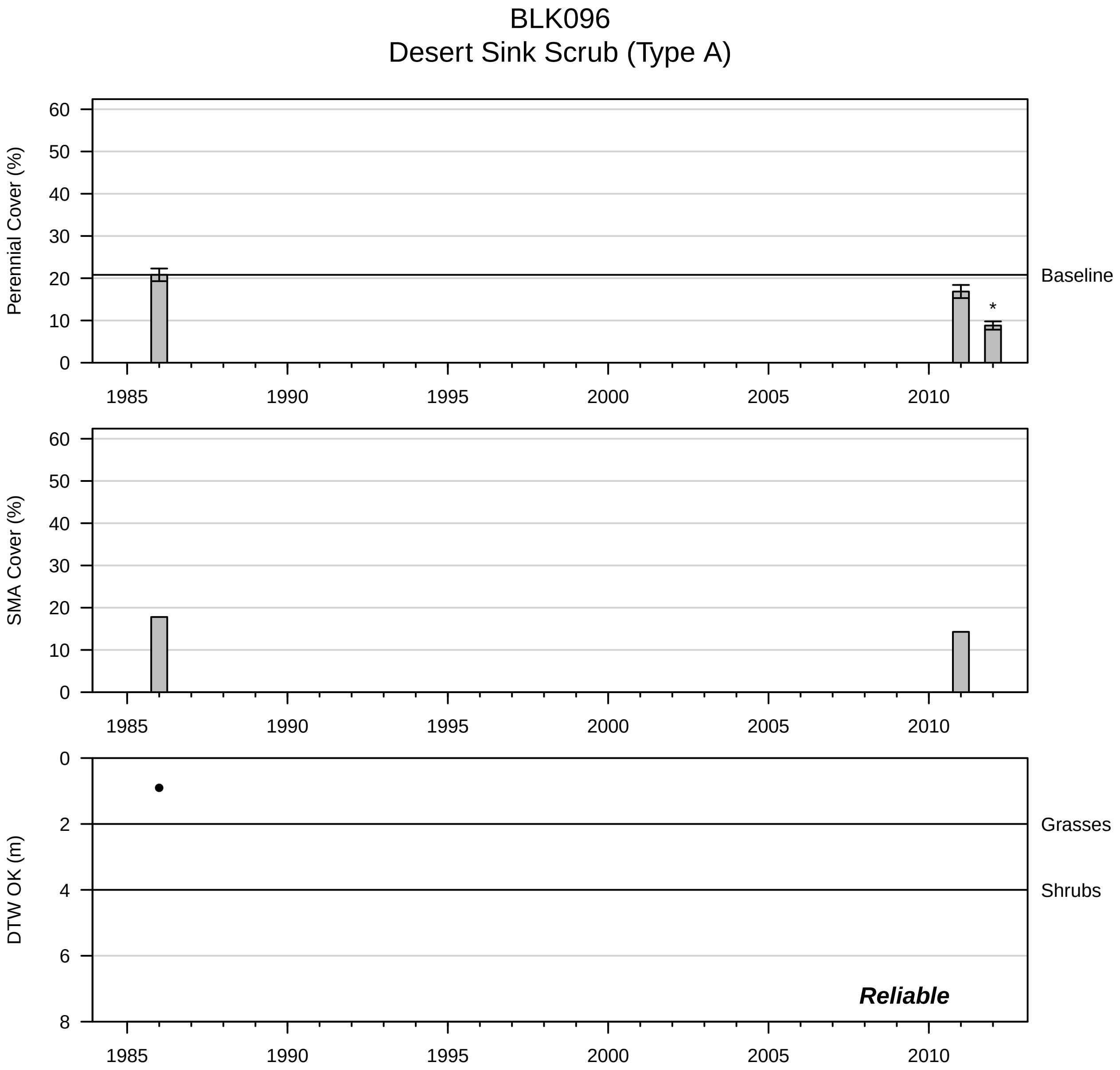

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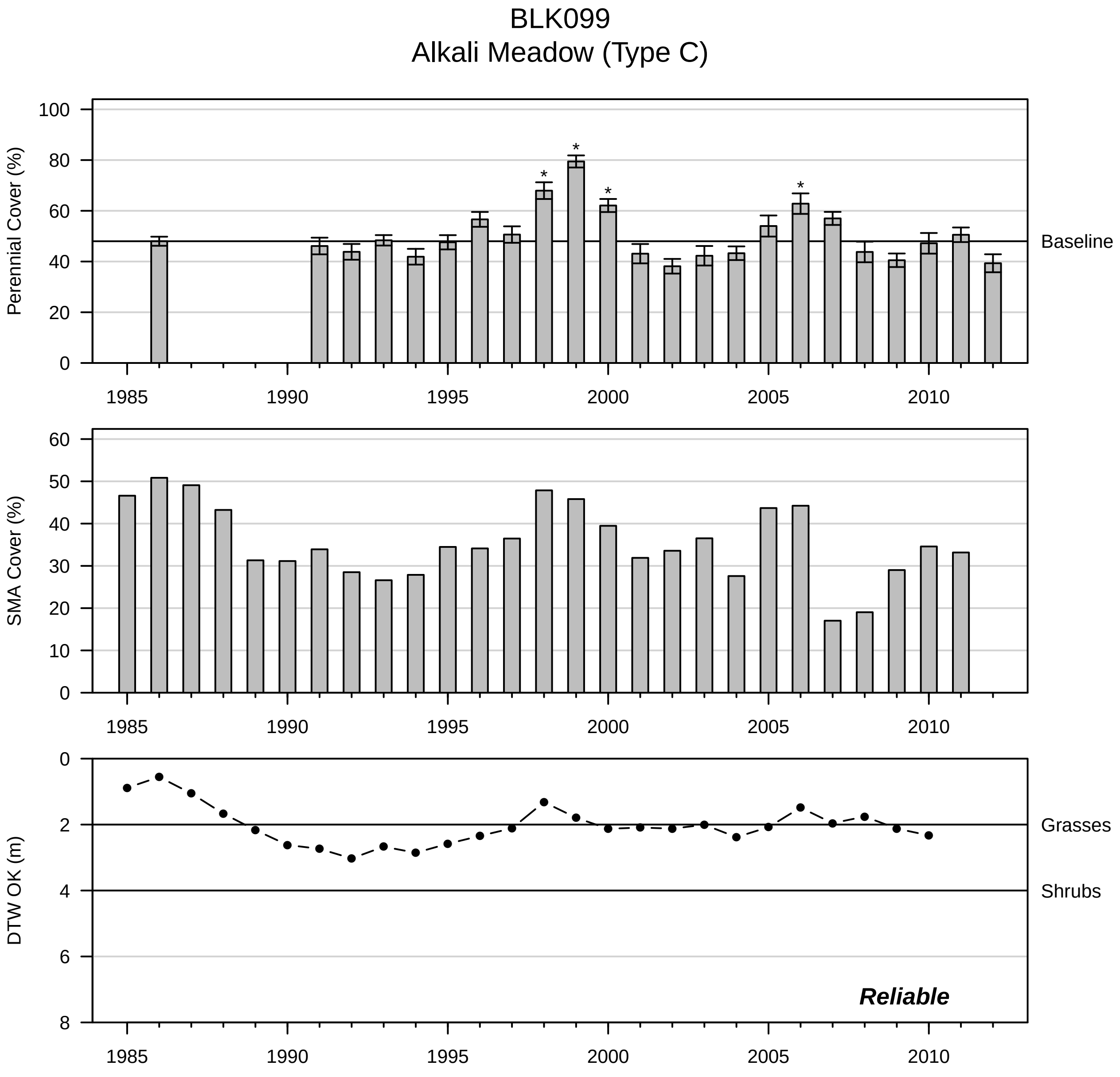

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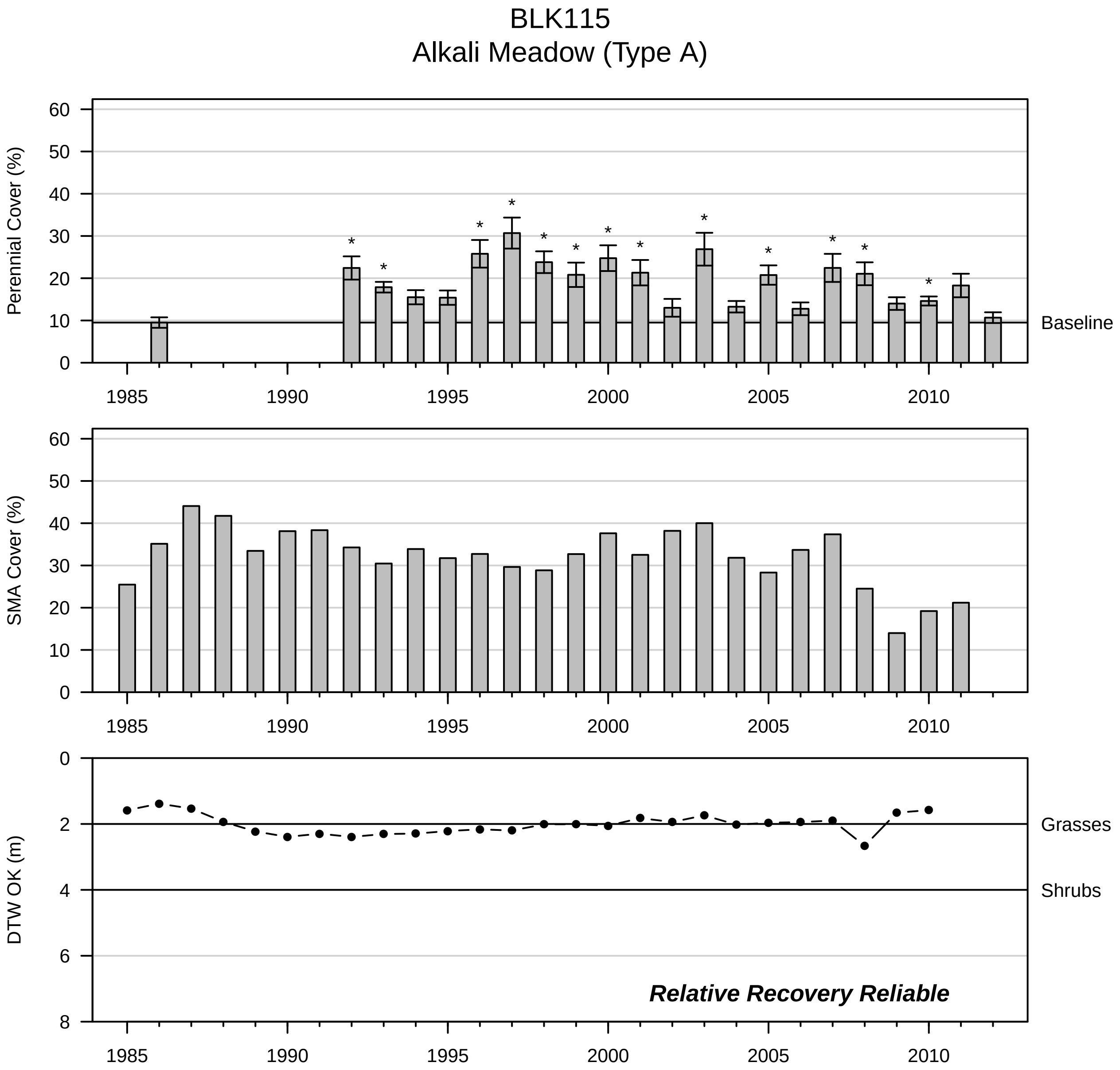
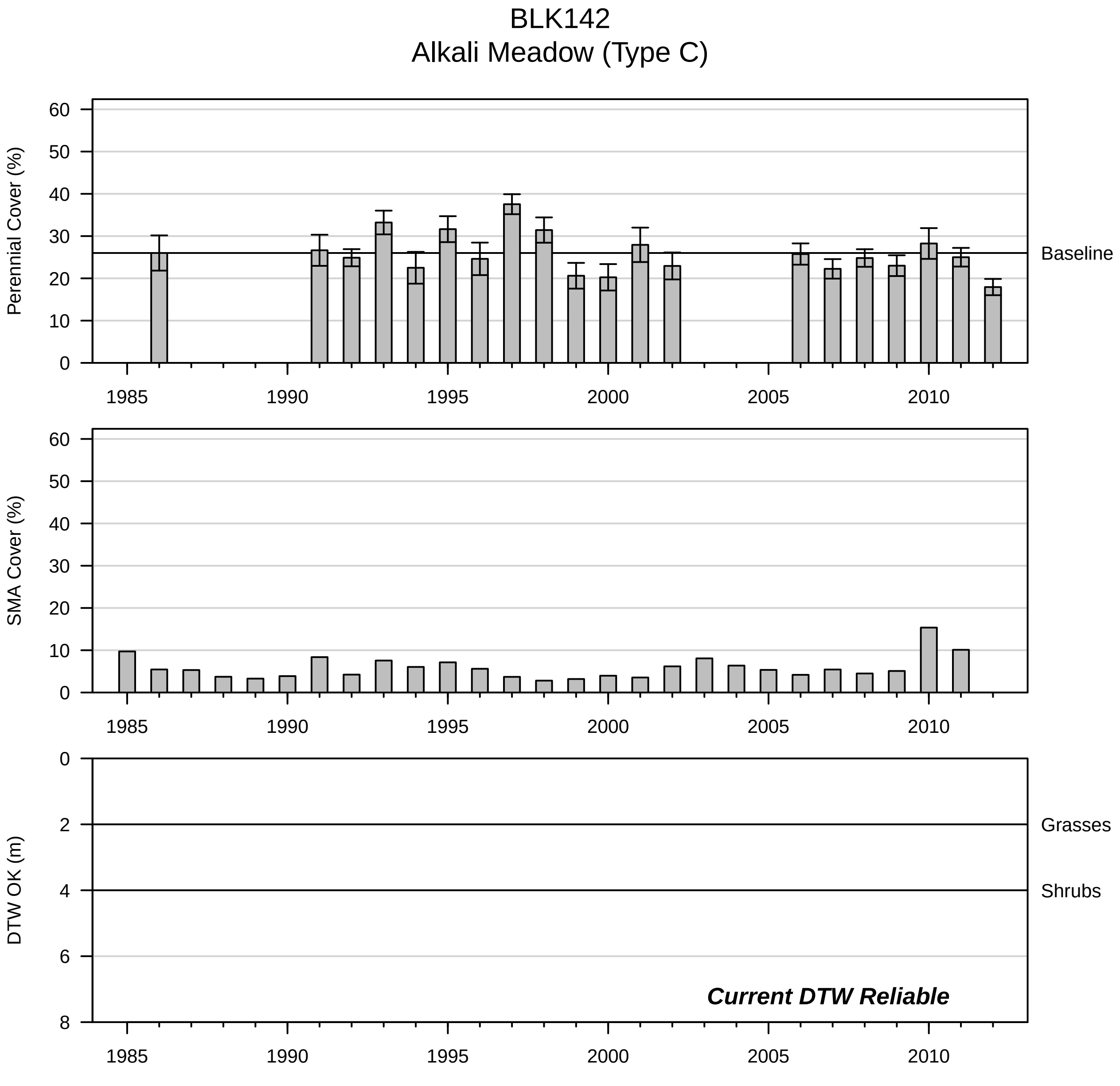


Figure 40: 2012 Control



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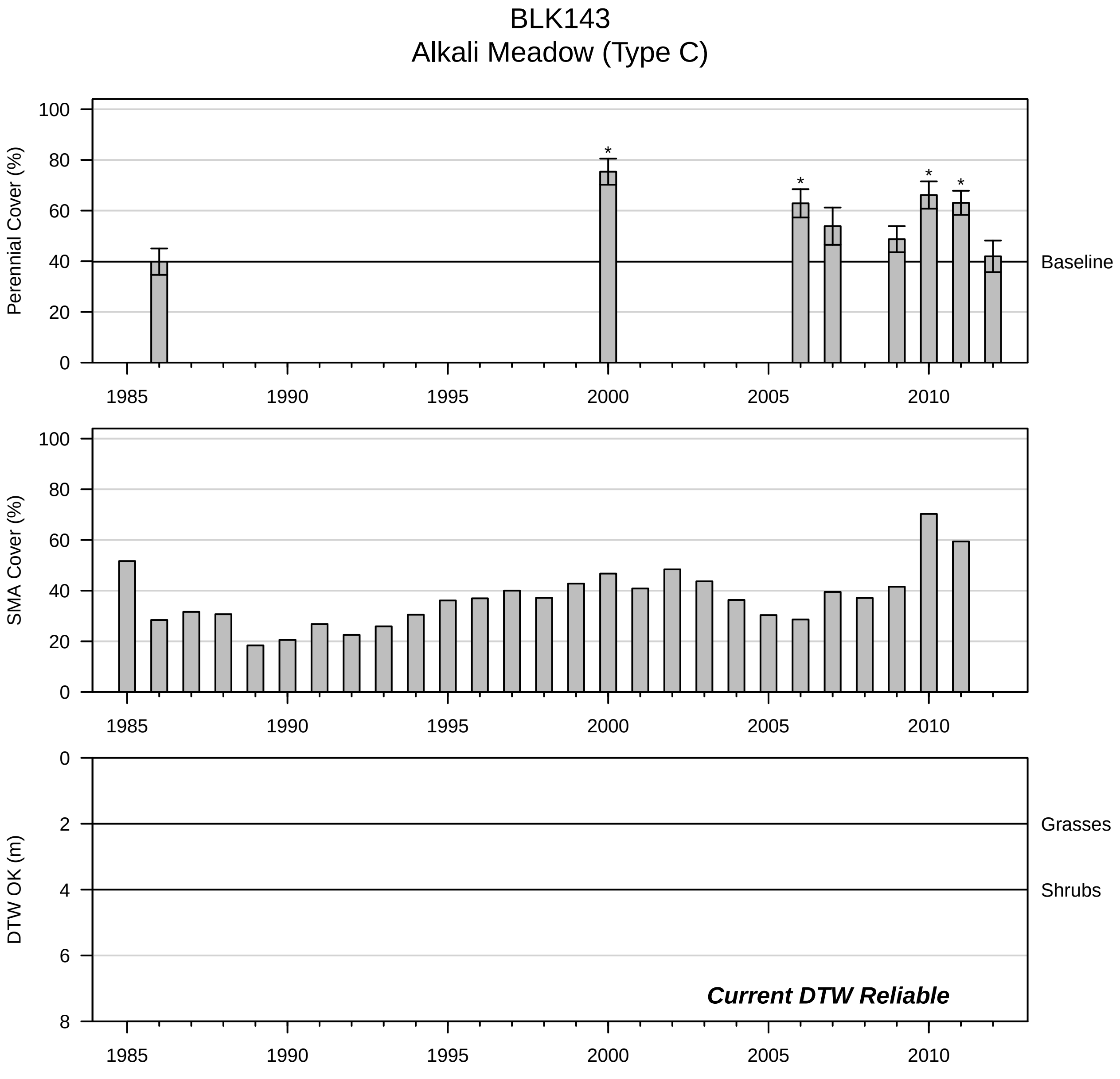


Figure 42: 2012 Wellfield

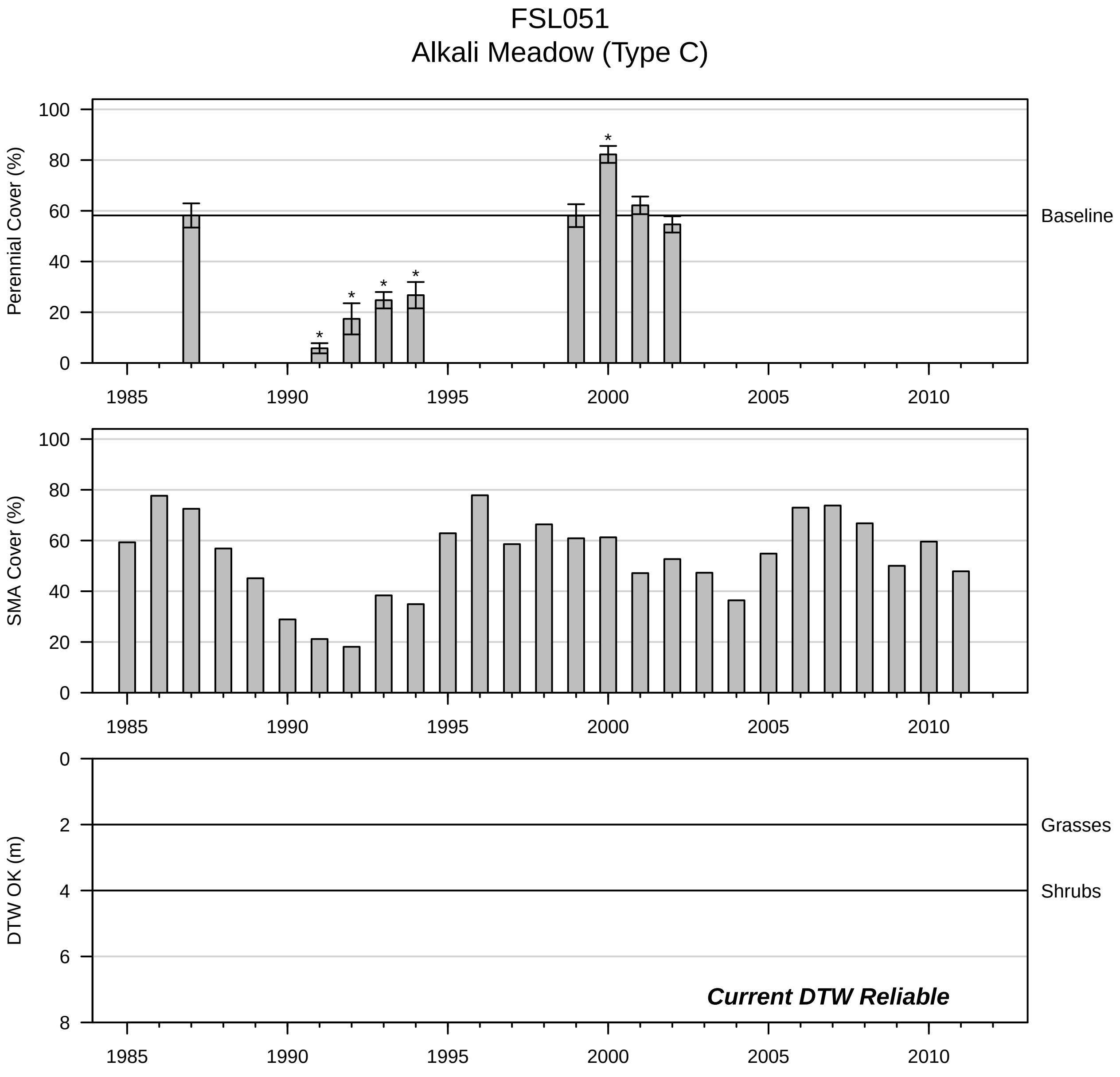
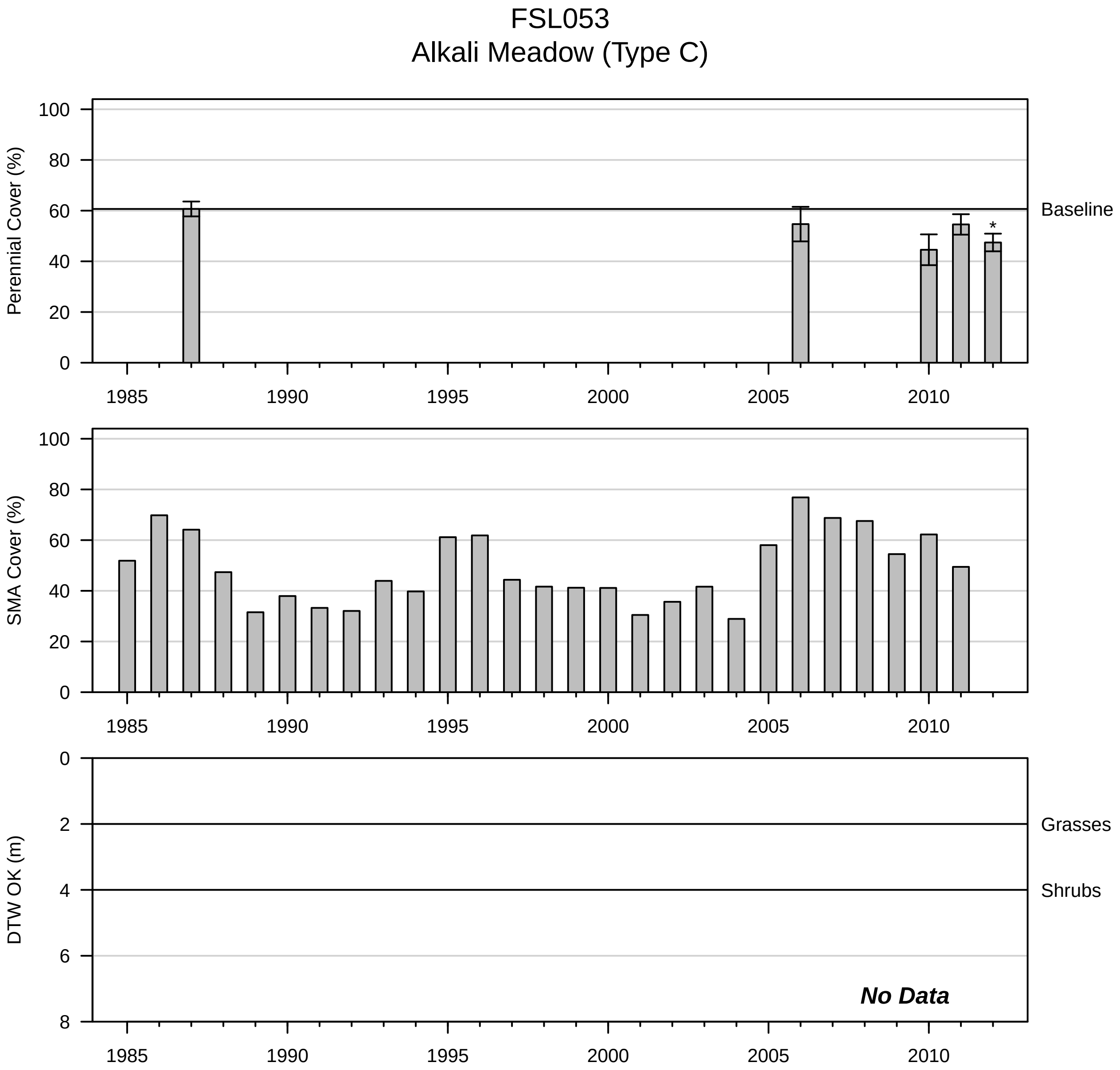


Figure 43: 2002 Wellfield



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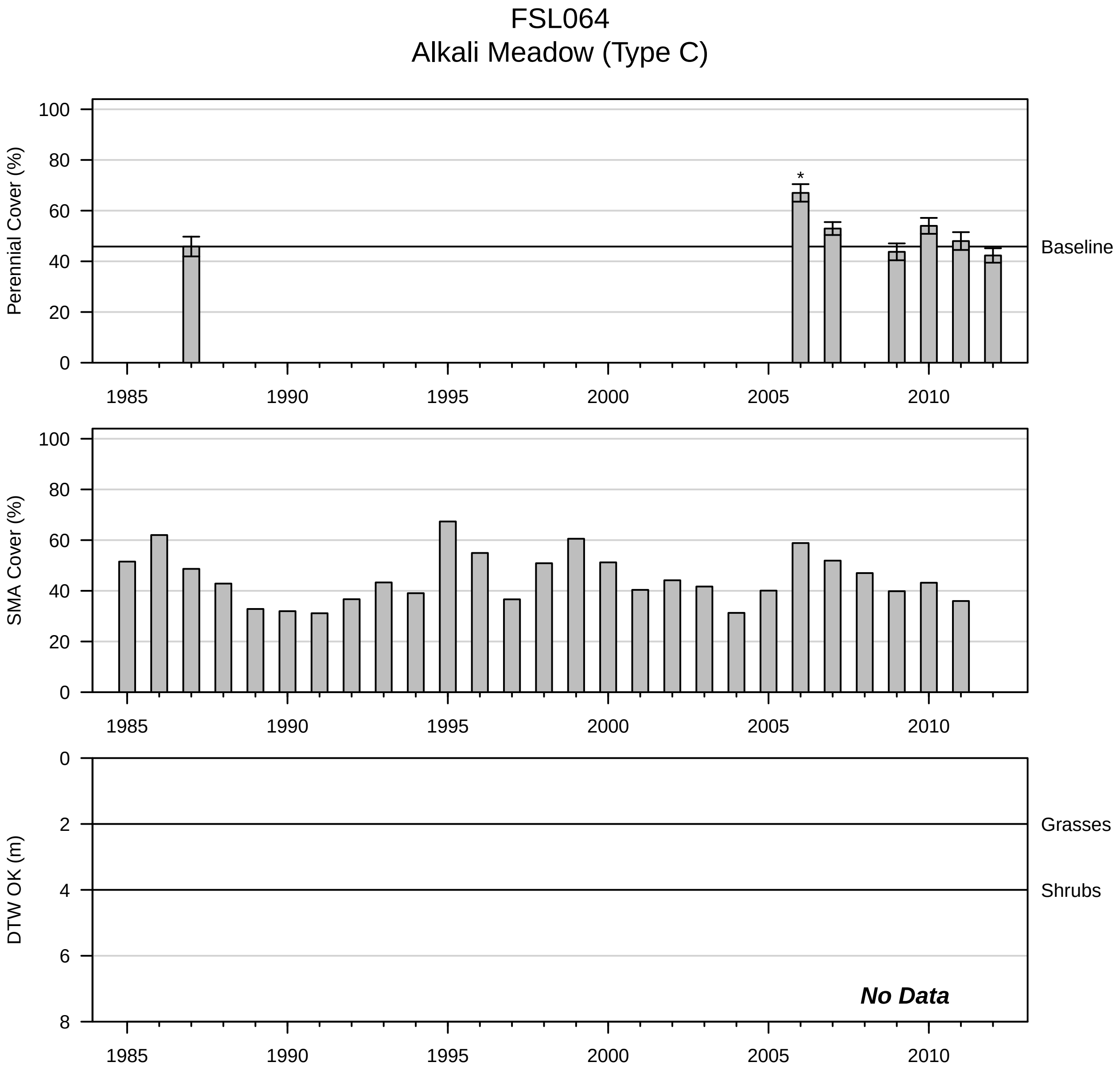

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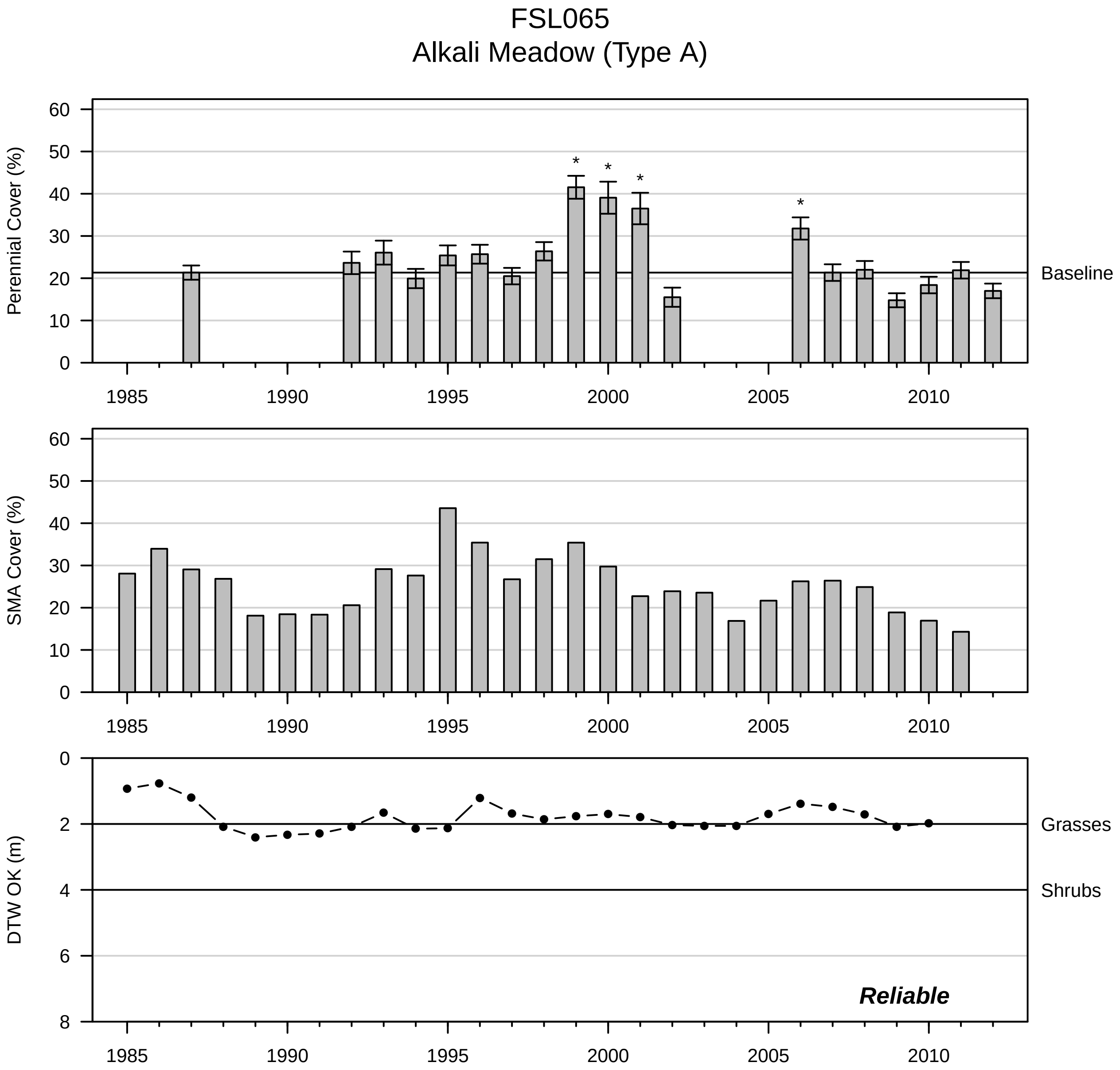


Figure 46: 2012 Wellfield

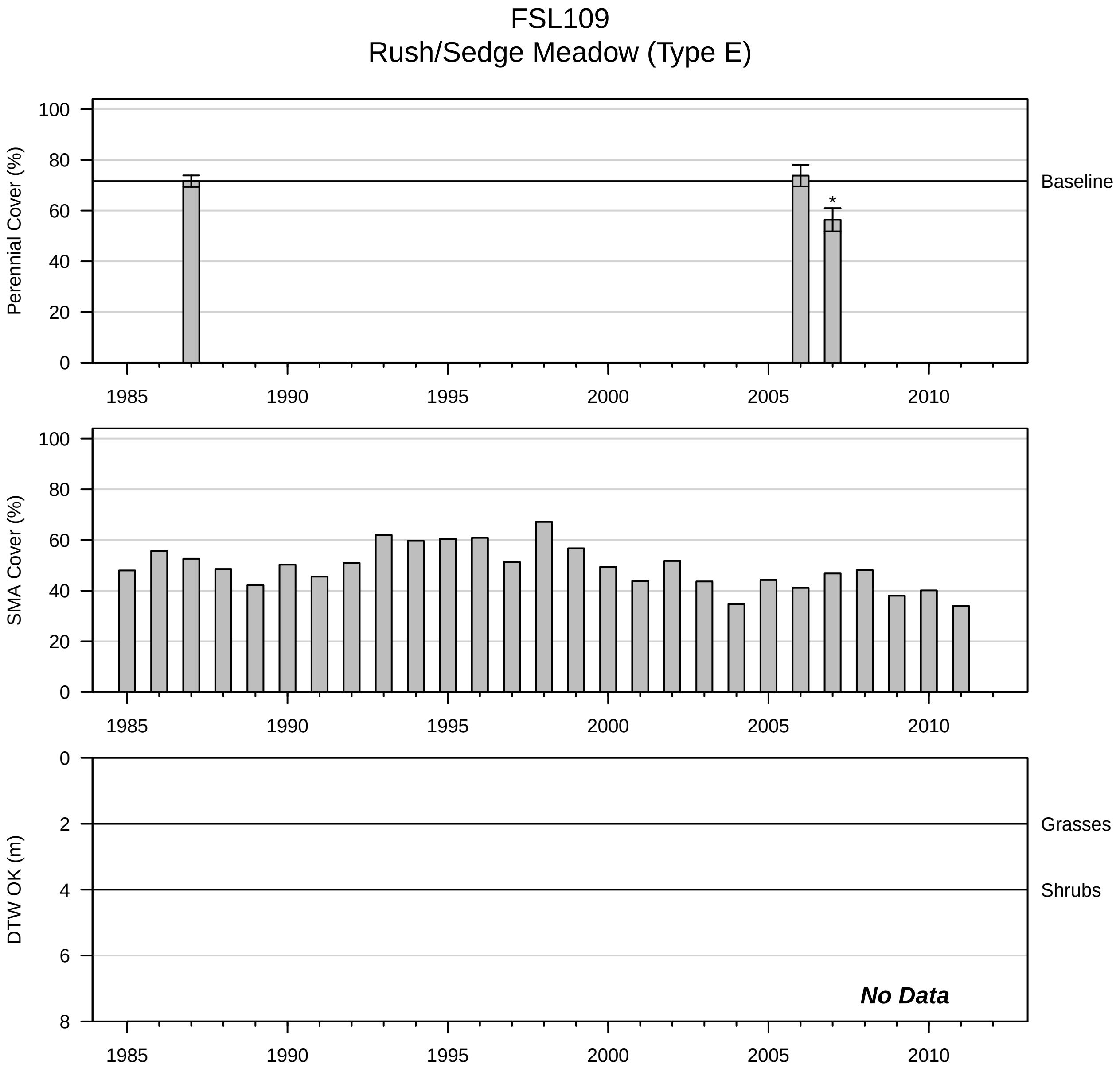


Figure 47: 2007 Control

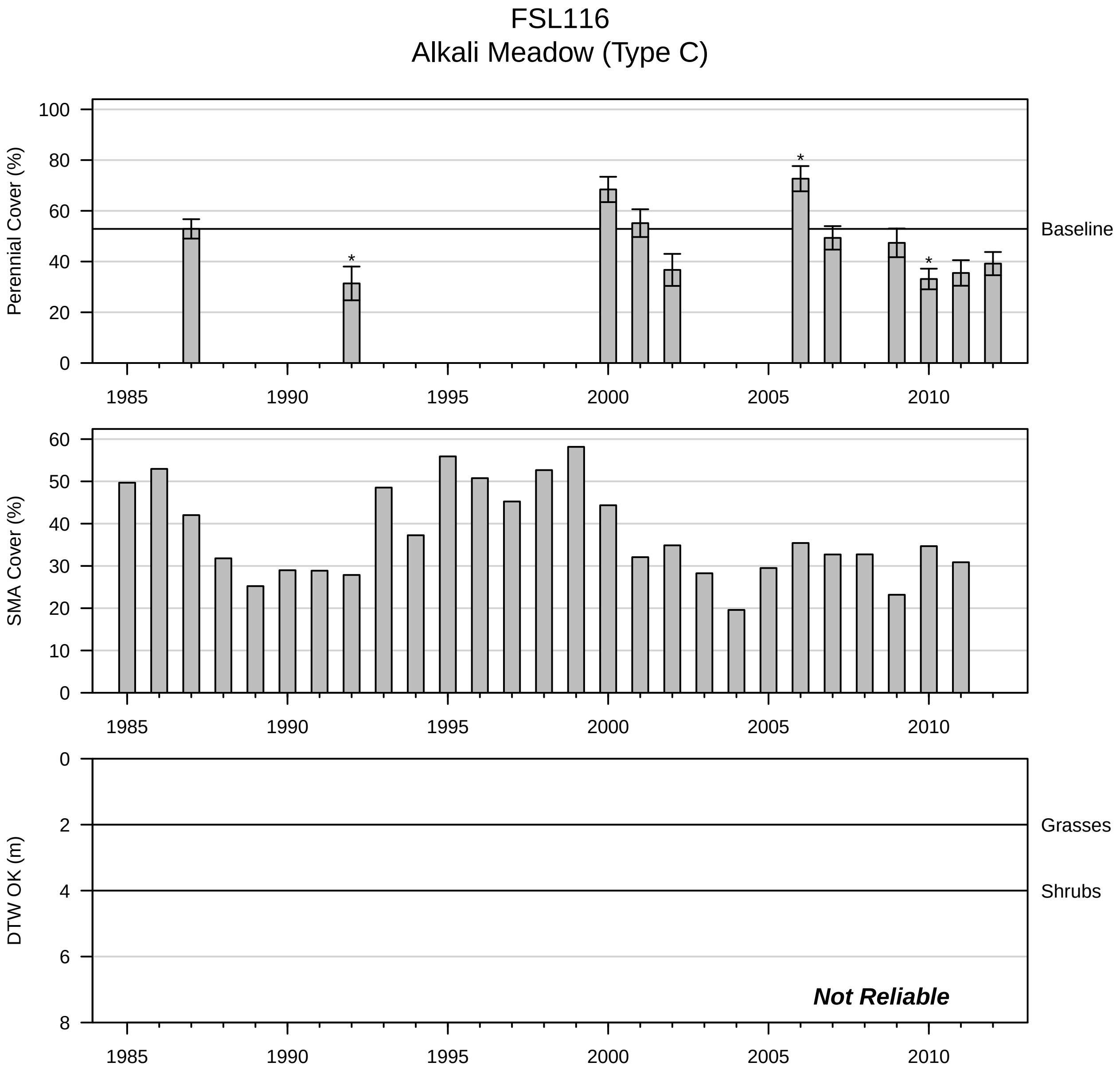


Figure 48: 2012 Wellfield

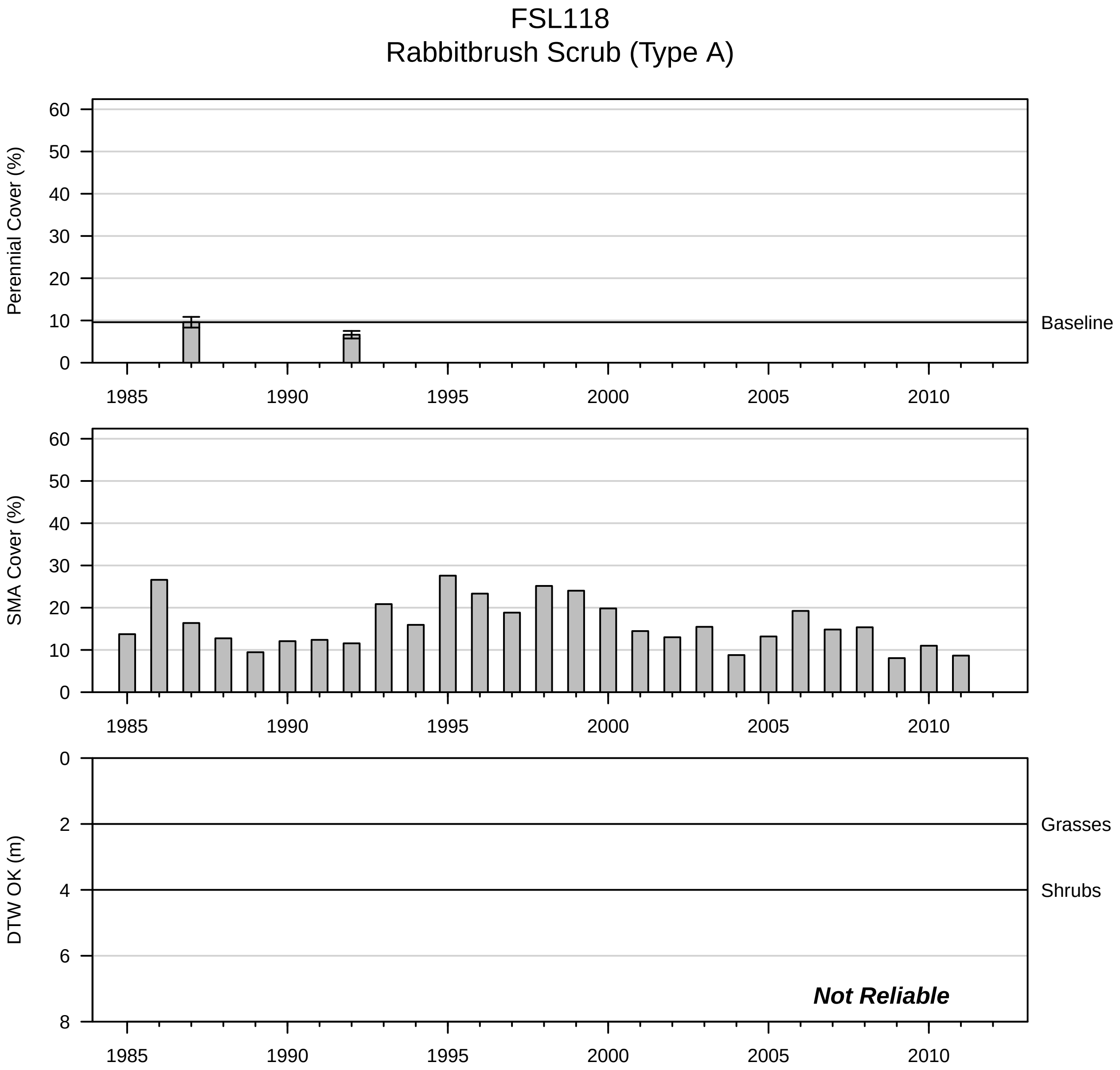
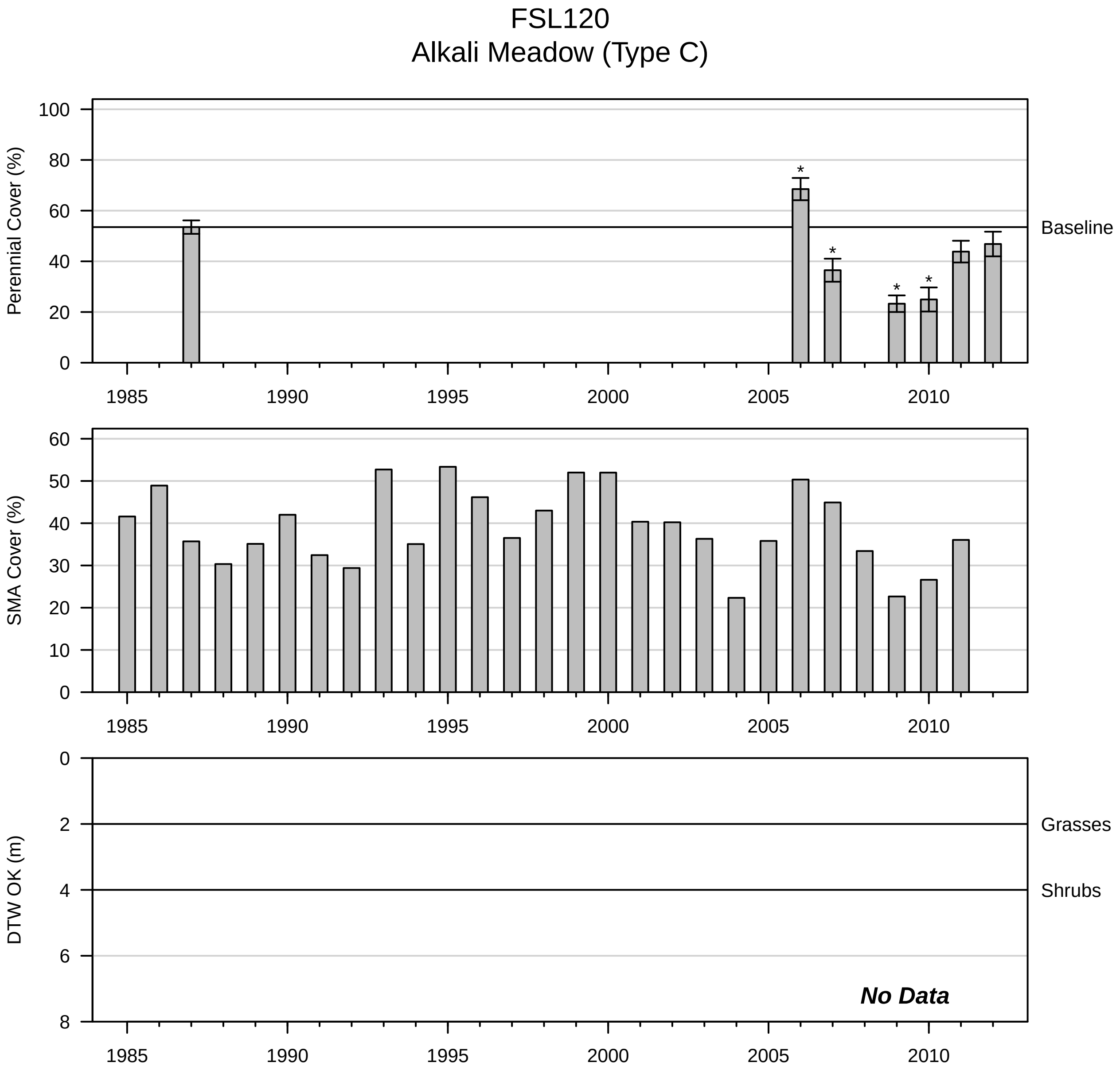


Figure 49: 1992 Wellfield



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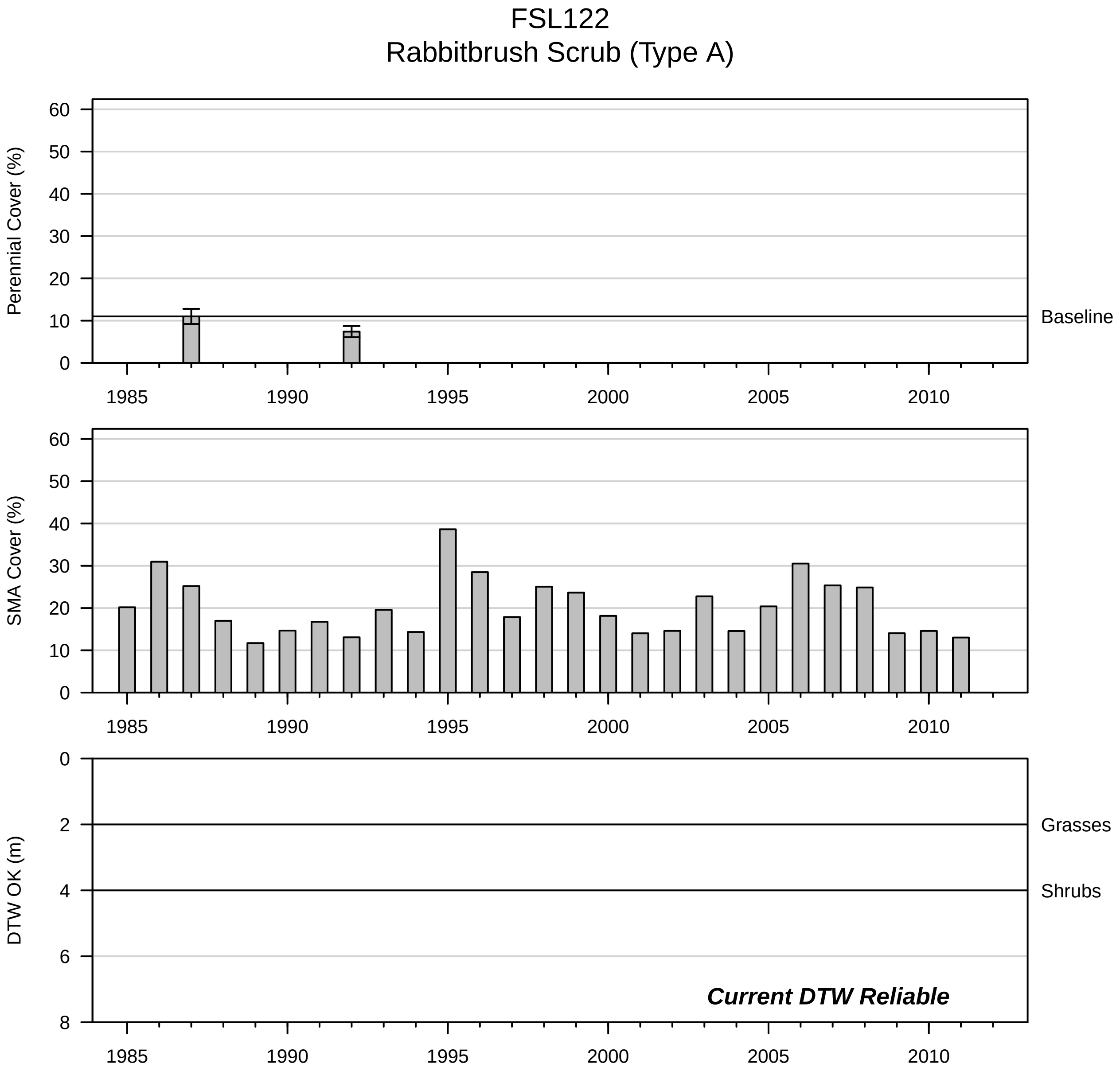
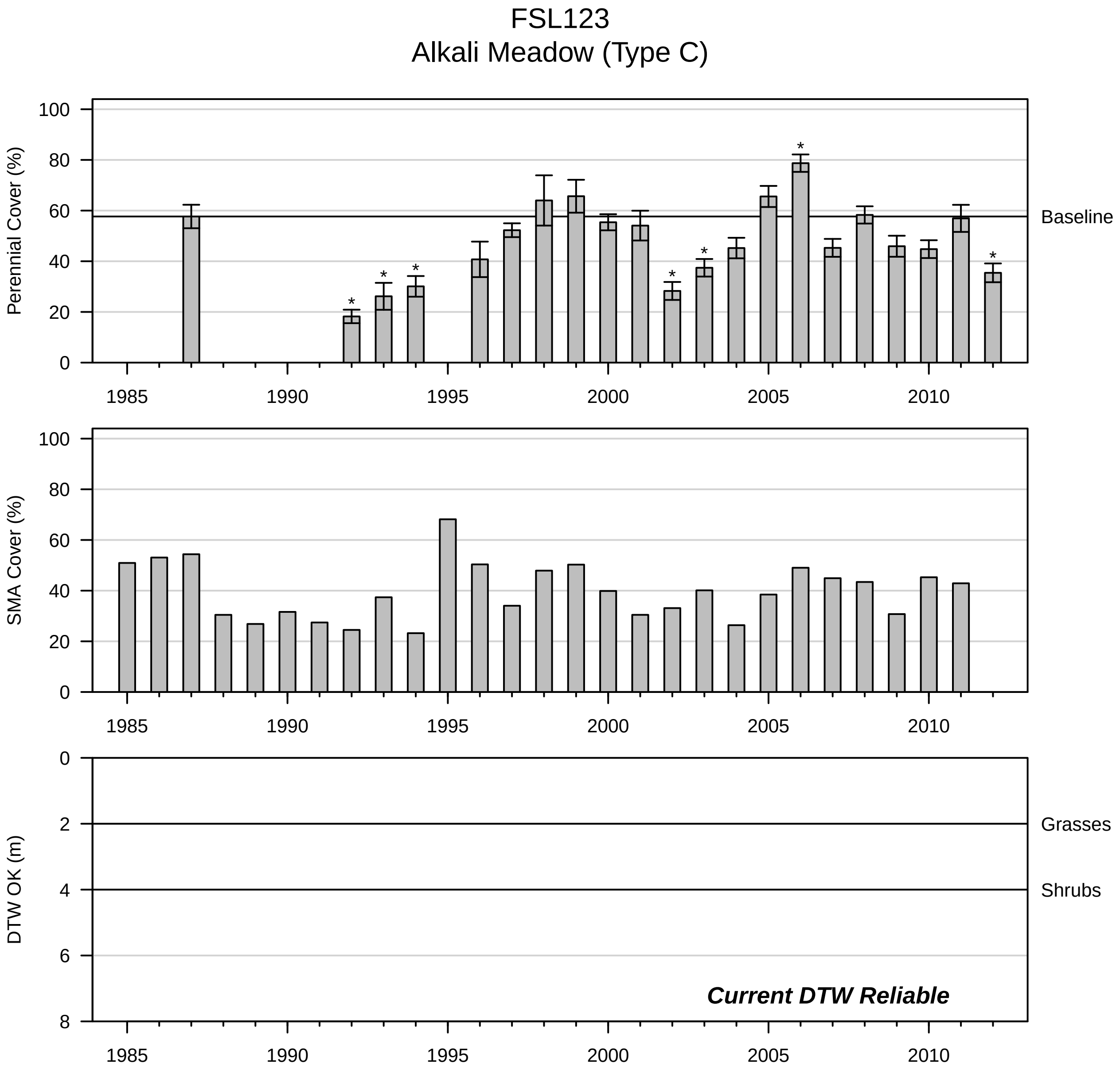


Figure 51: 1992 Wellfield



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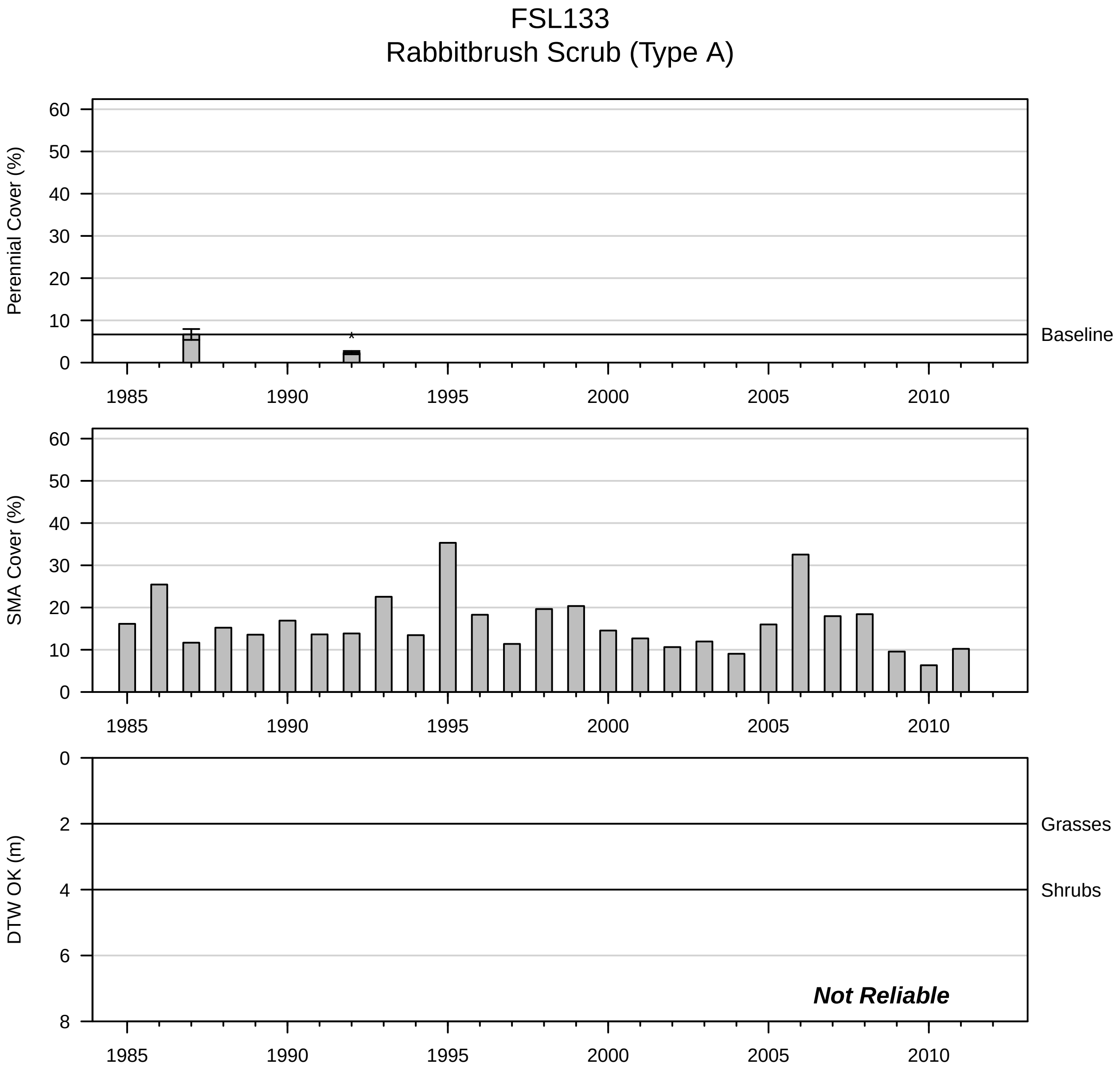


Figure 53: 1992 Wellfield

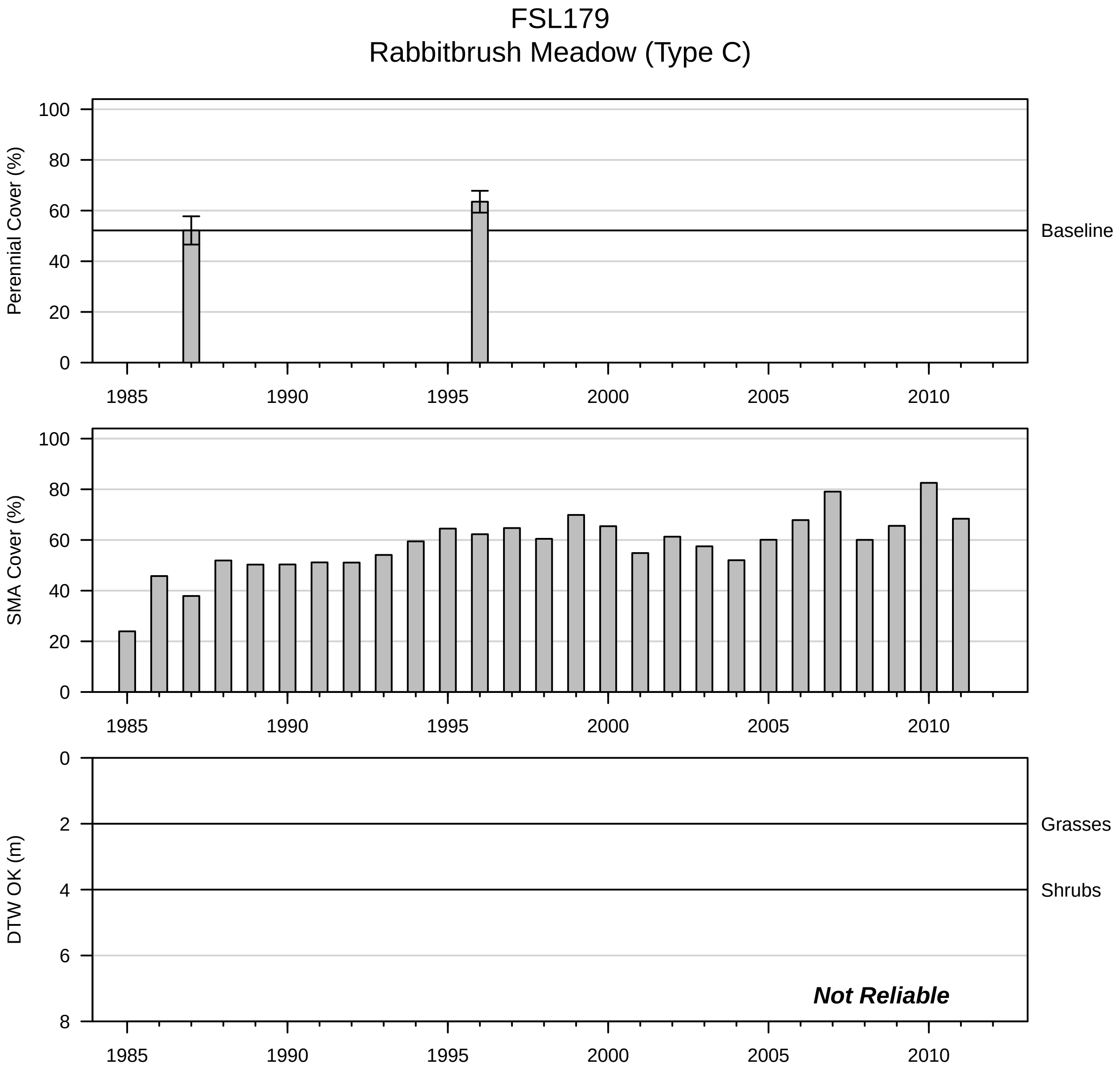


Figure 54: 1996 Control

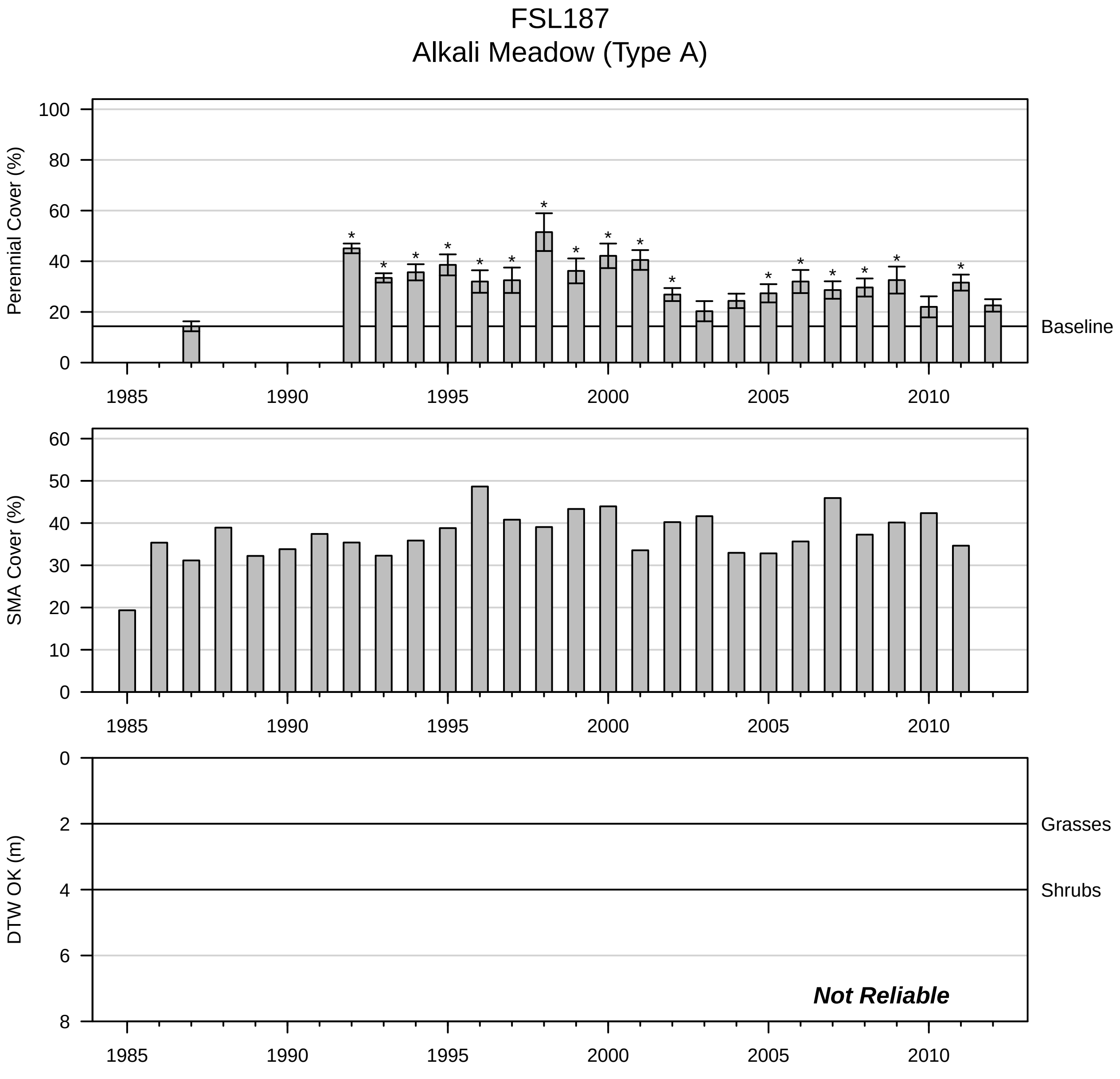


Figure 55: 2012 Control

FSP004
Rabbitbrush Meadow (Type C)

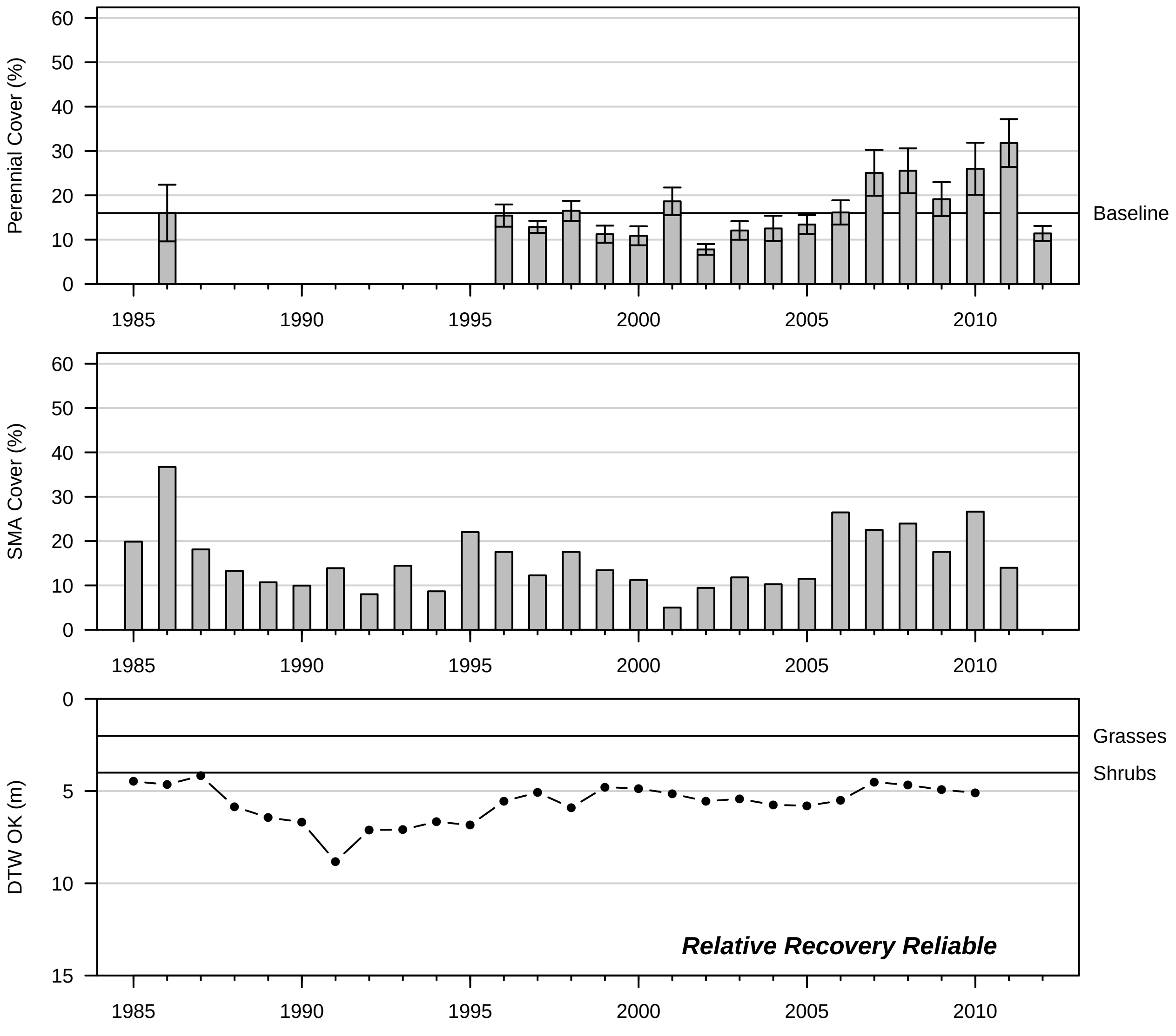


Figure 56: 2012 Wellfield

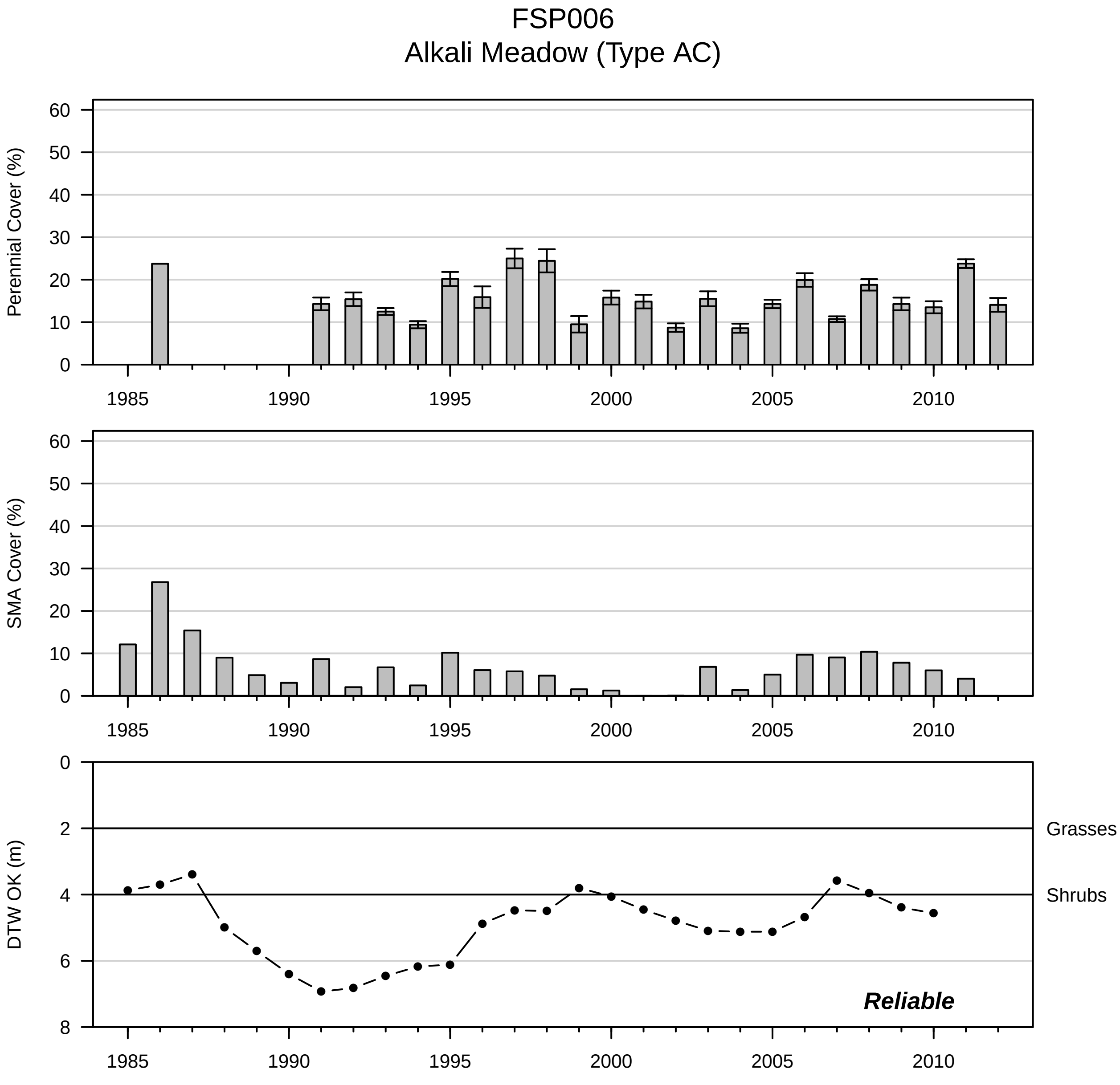


Figure 57: 2012 Wellfield

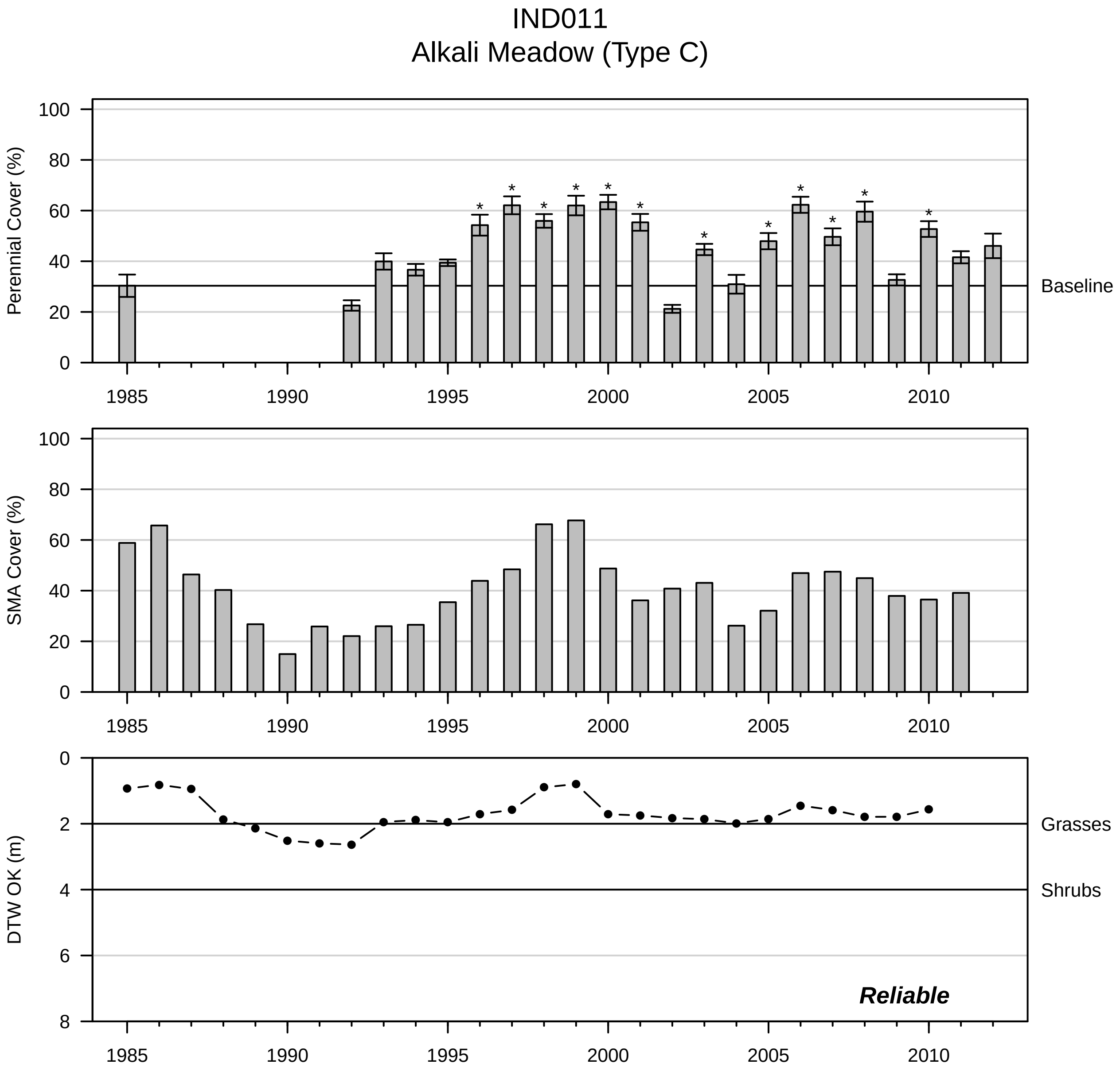
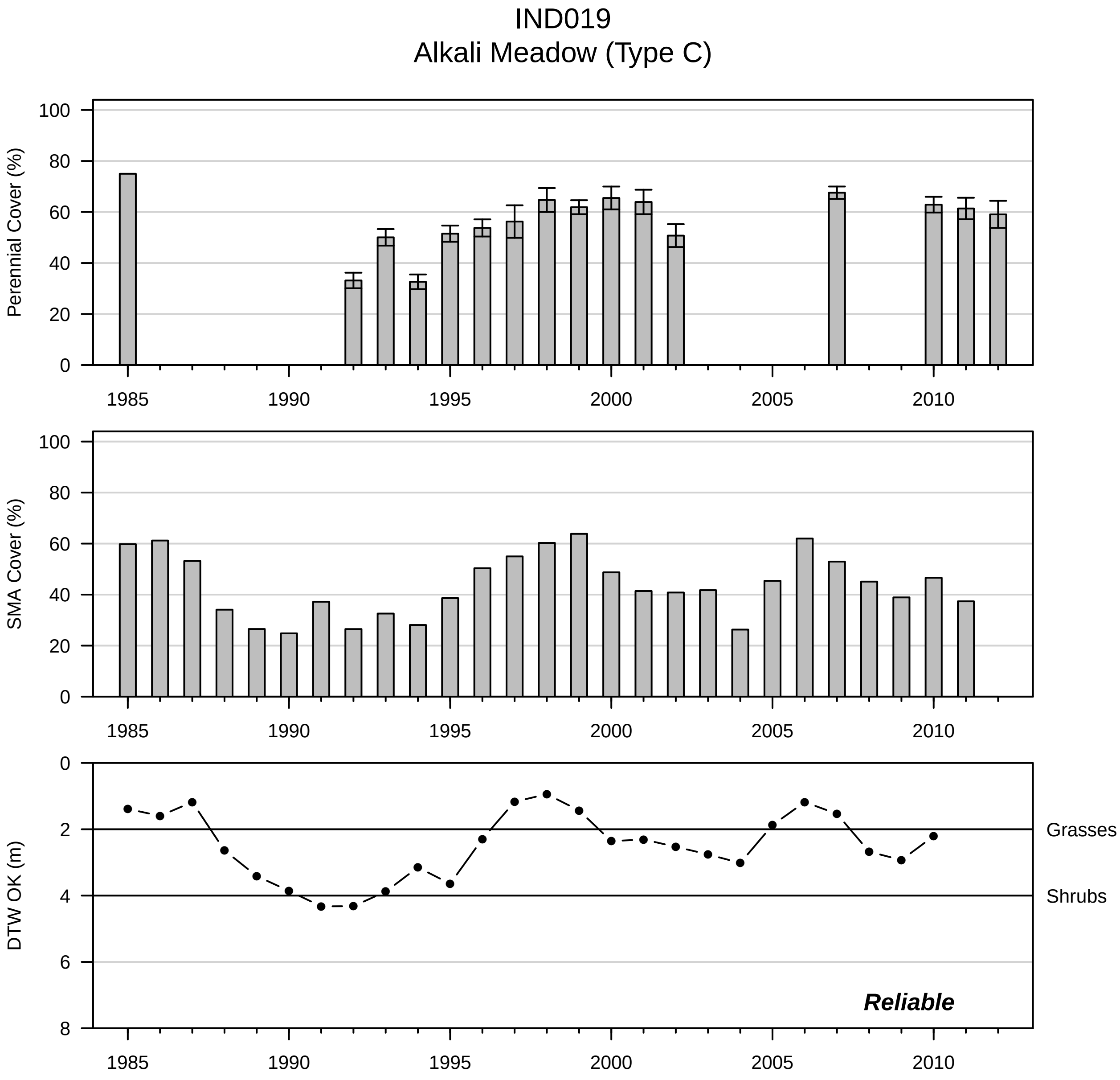


Figure 58: 2012 Wellfield



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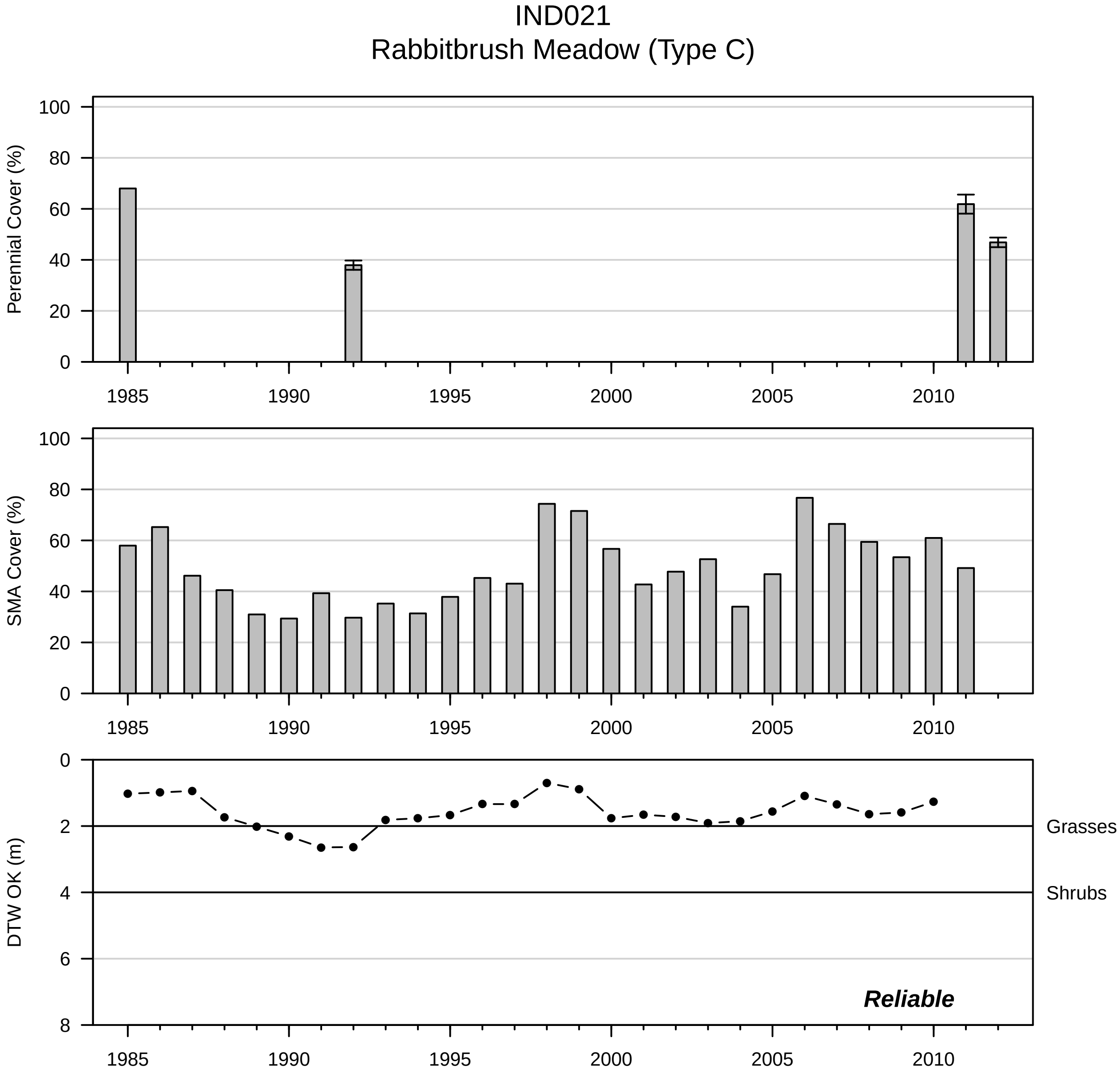

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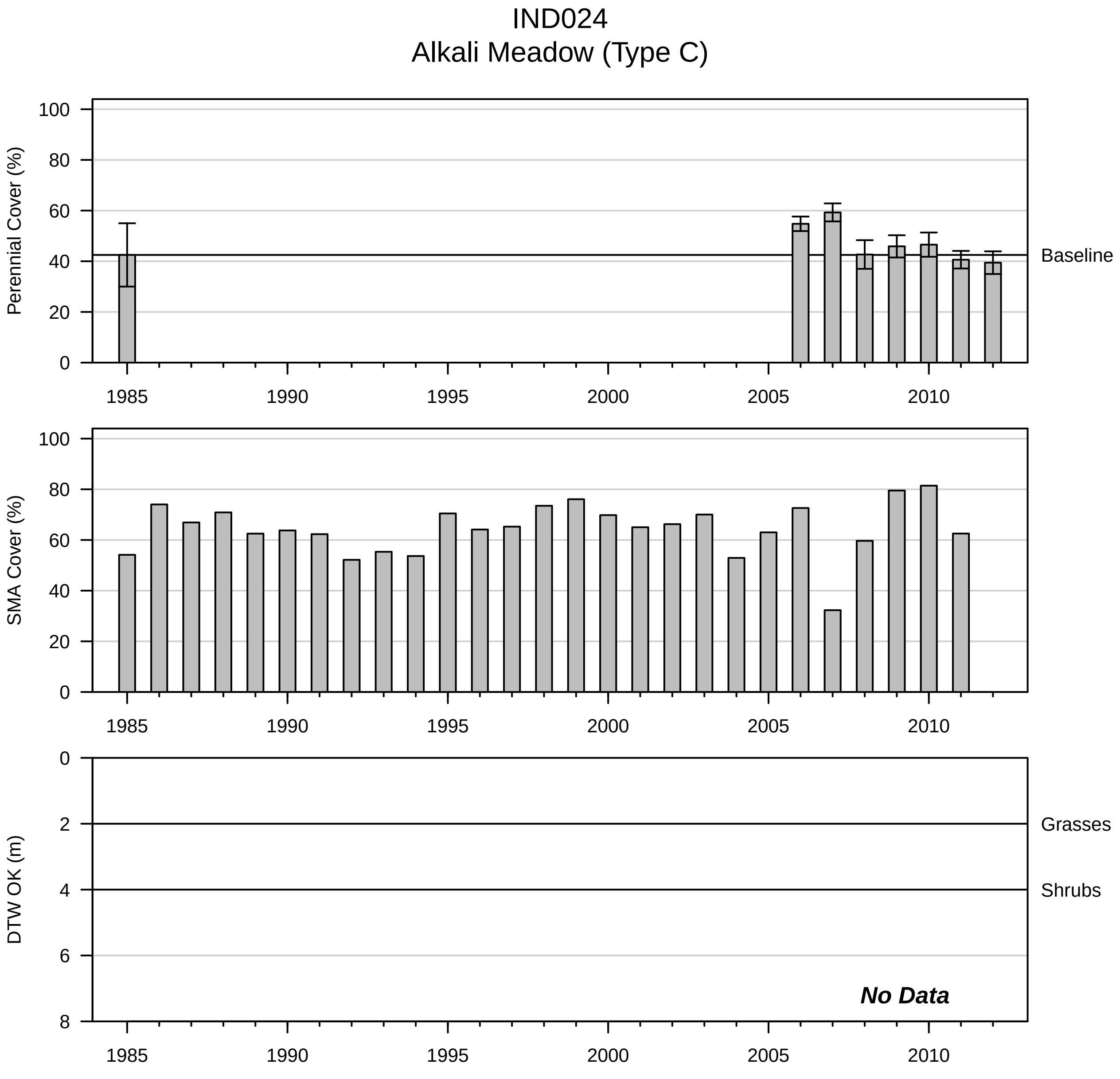

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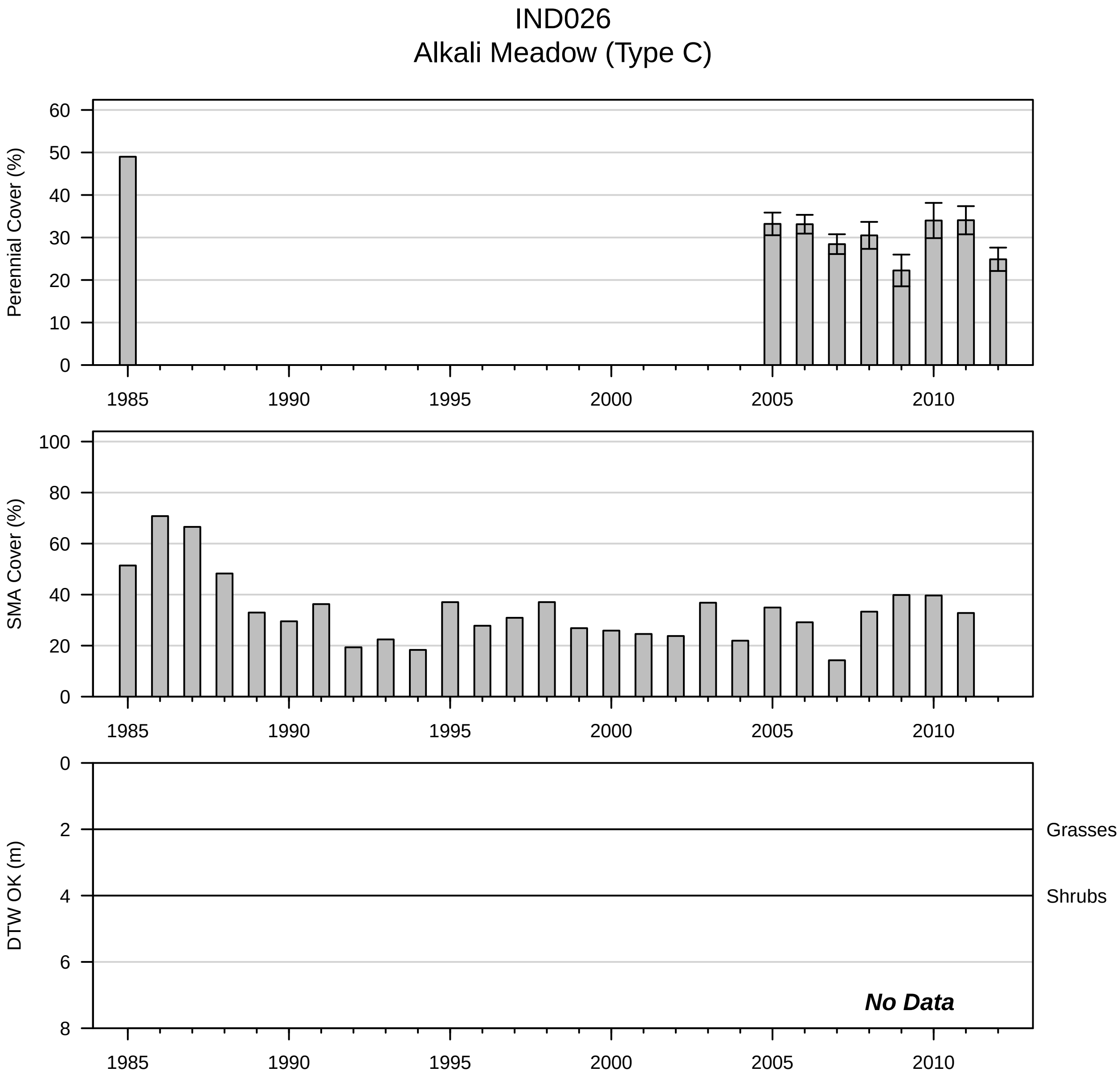


Figure 62: 2012 Wellfield

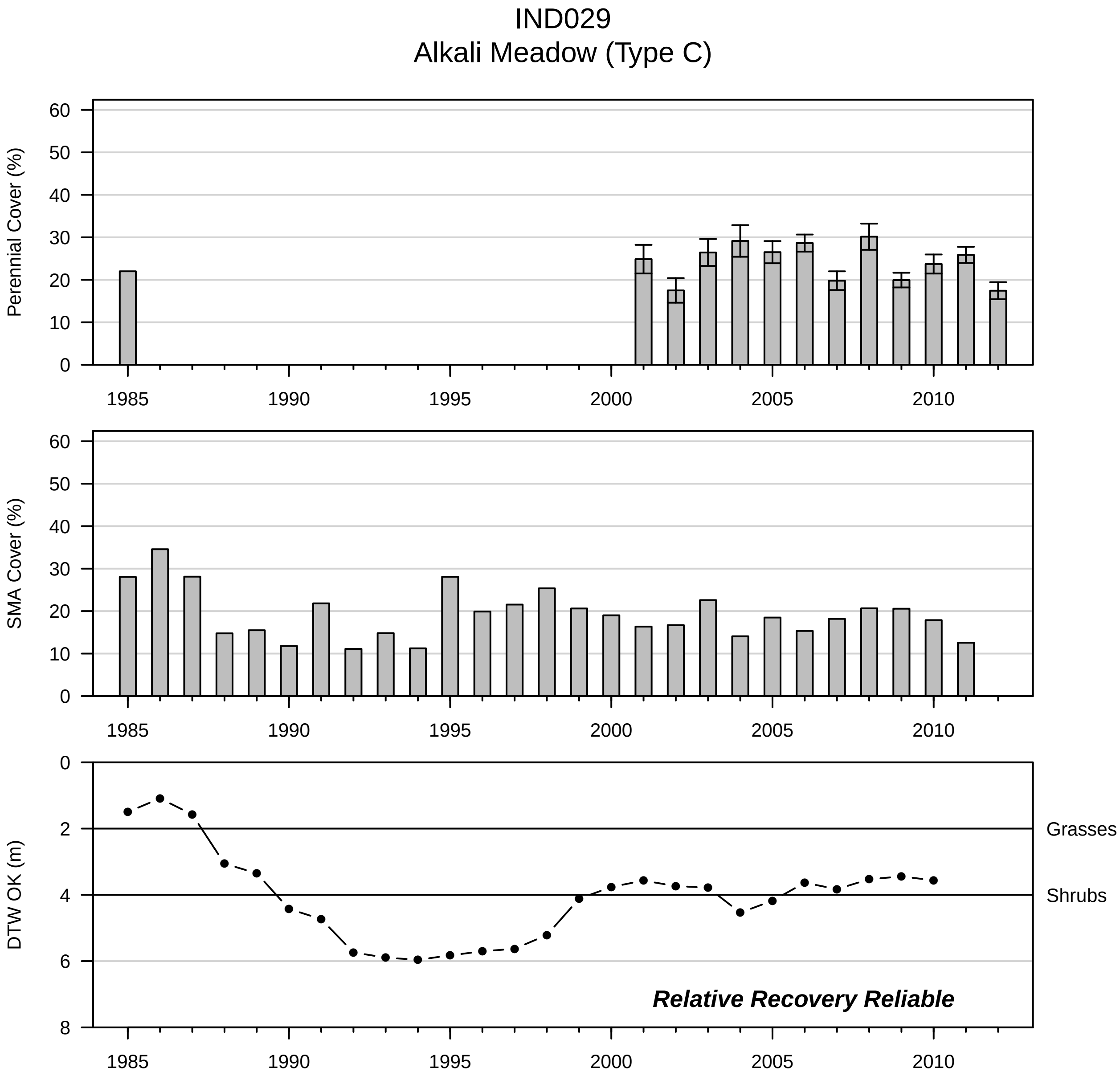


Figure 63: 2012 Wellfield

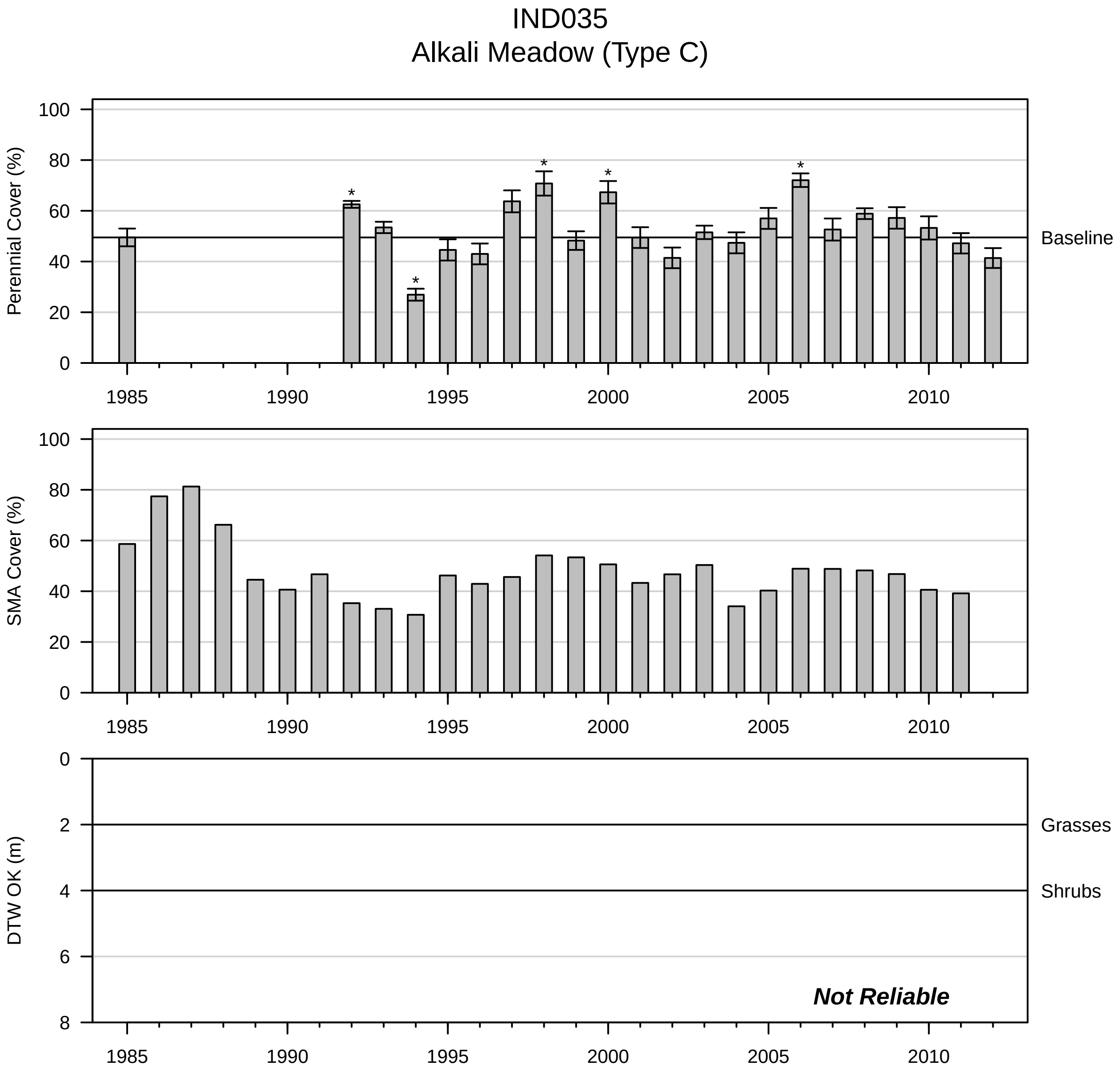


Figure 64: 2012 Wellfield

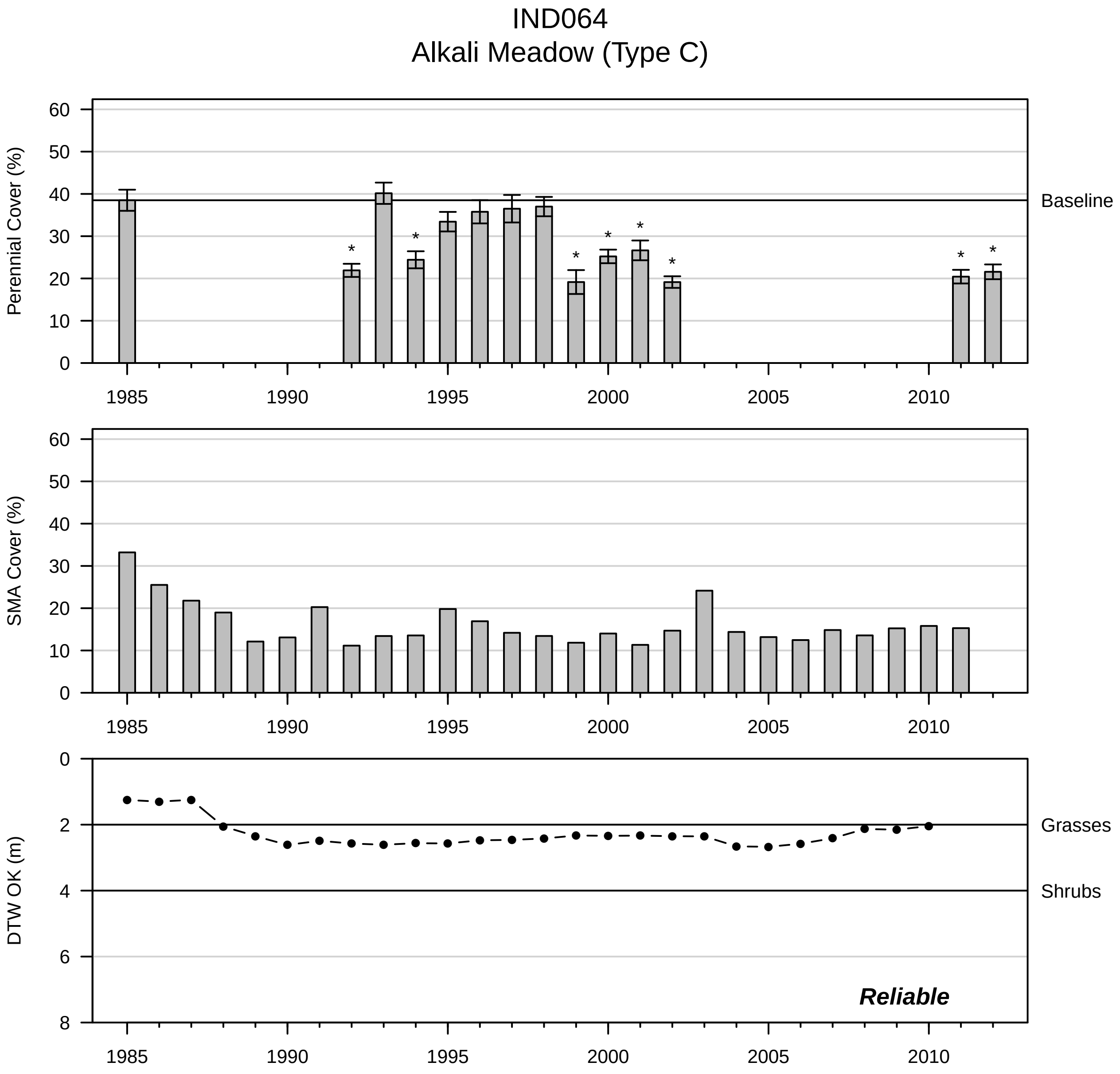


Figure 65: 2012 Control

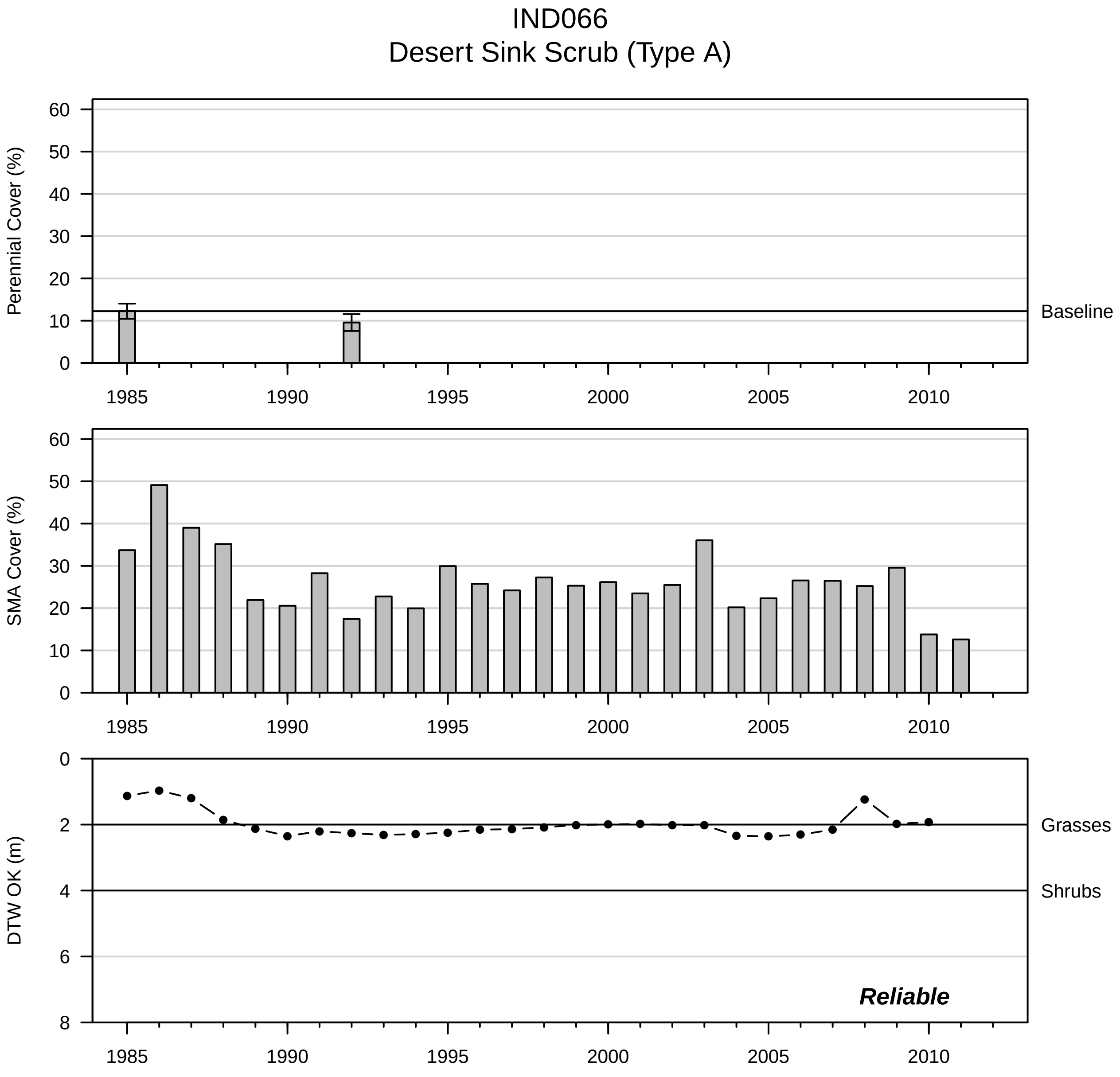


Figure 66: 1992 Control

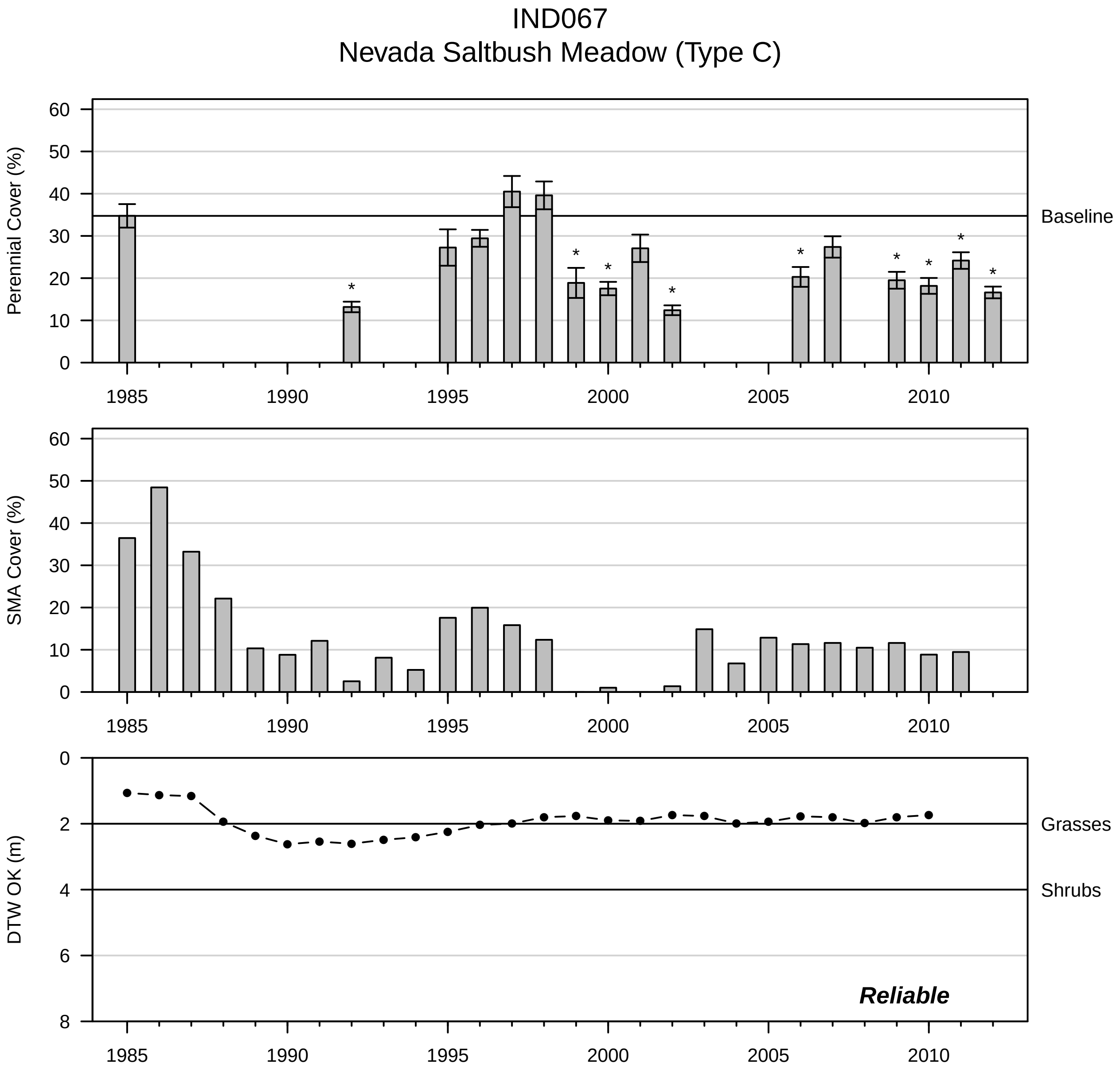


Figure 67: 2012 Control

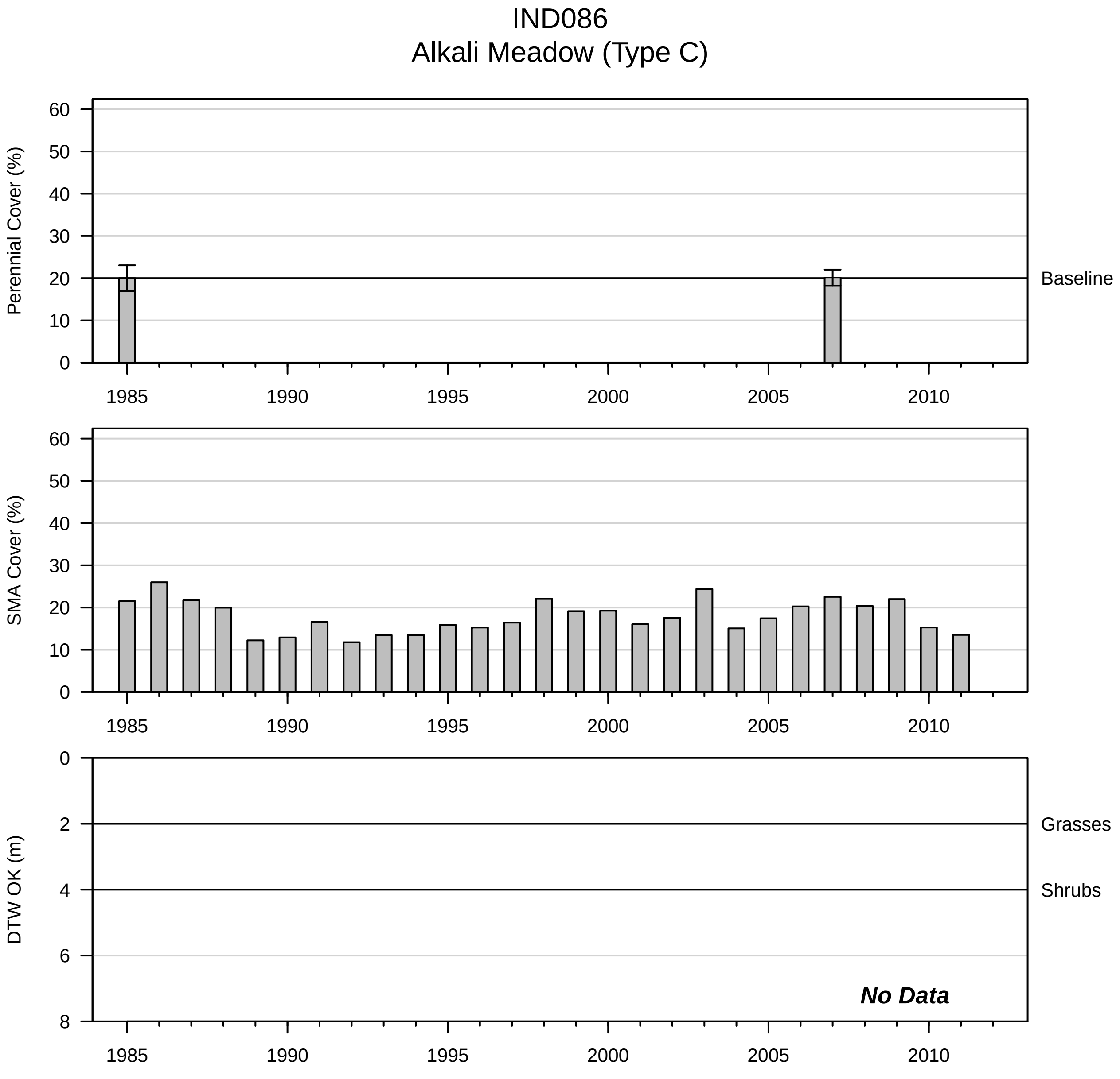


Figure 68: 2007 Control

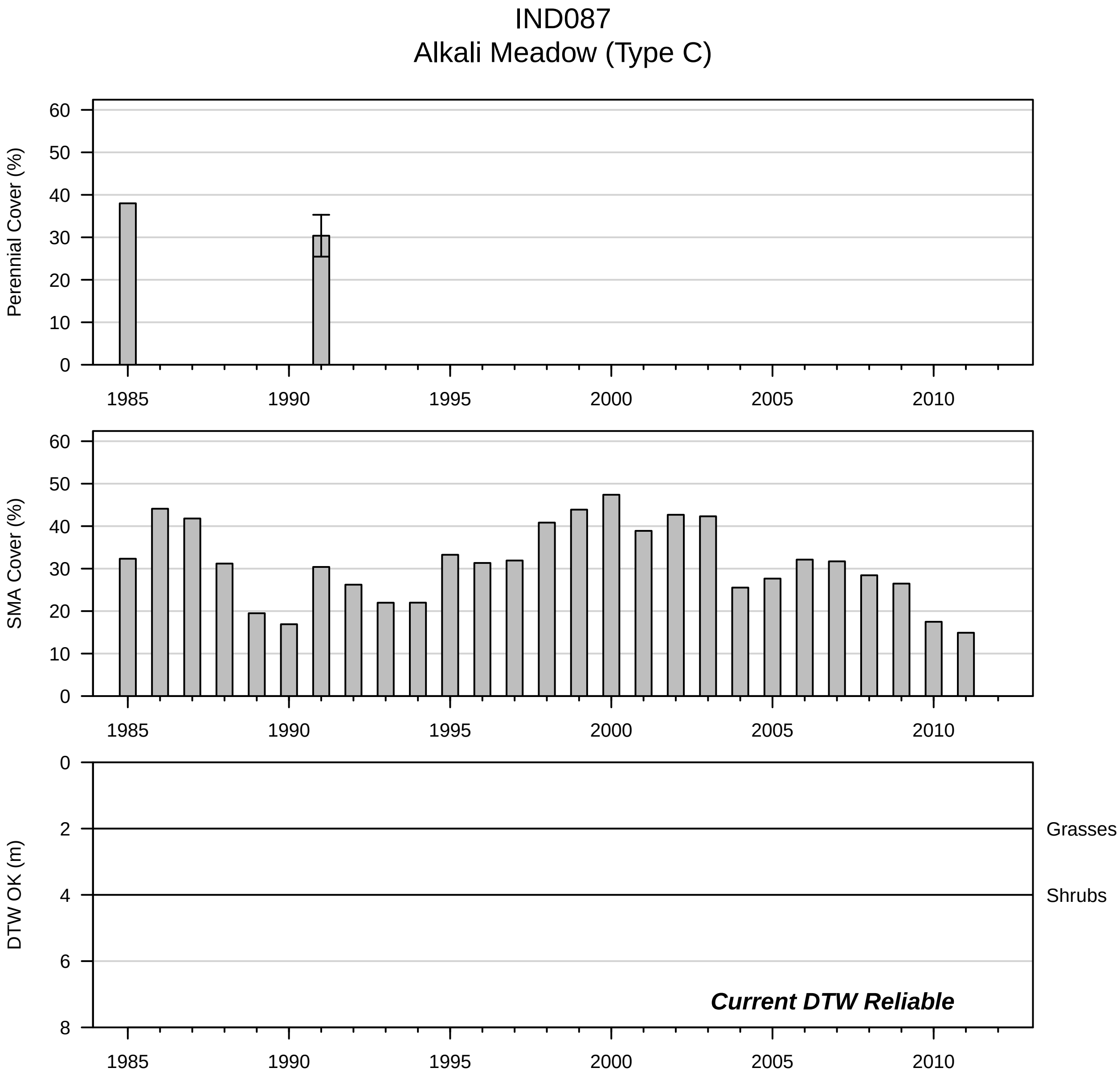


Figure 69: 1991 Control

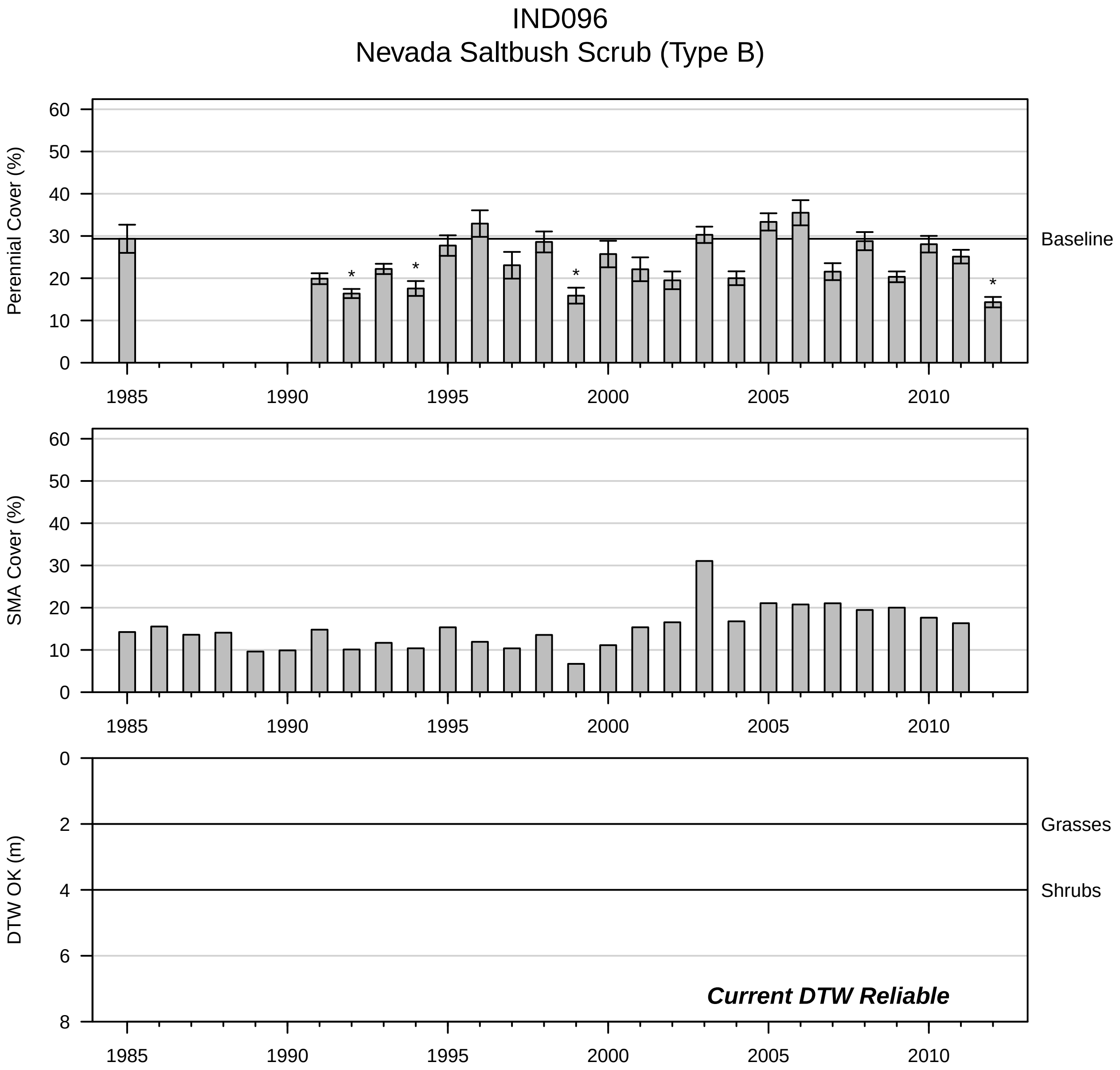


Figure 70: 2012 Control

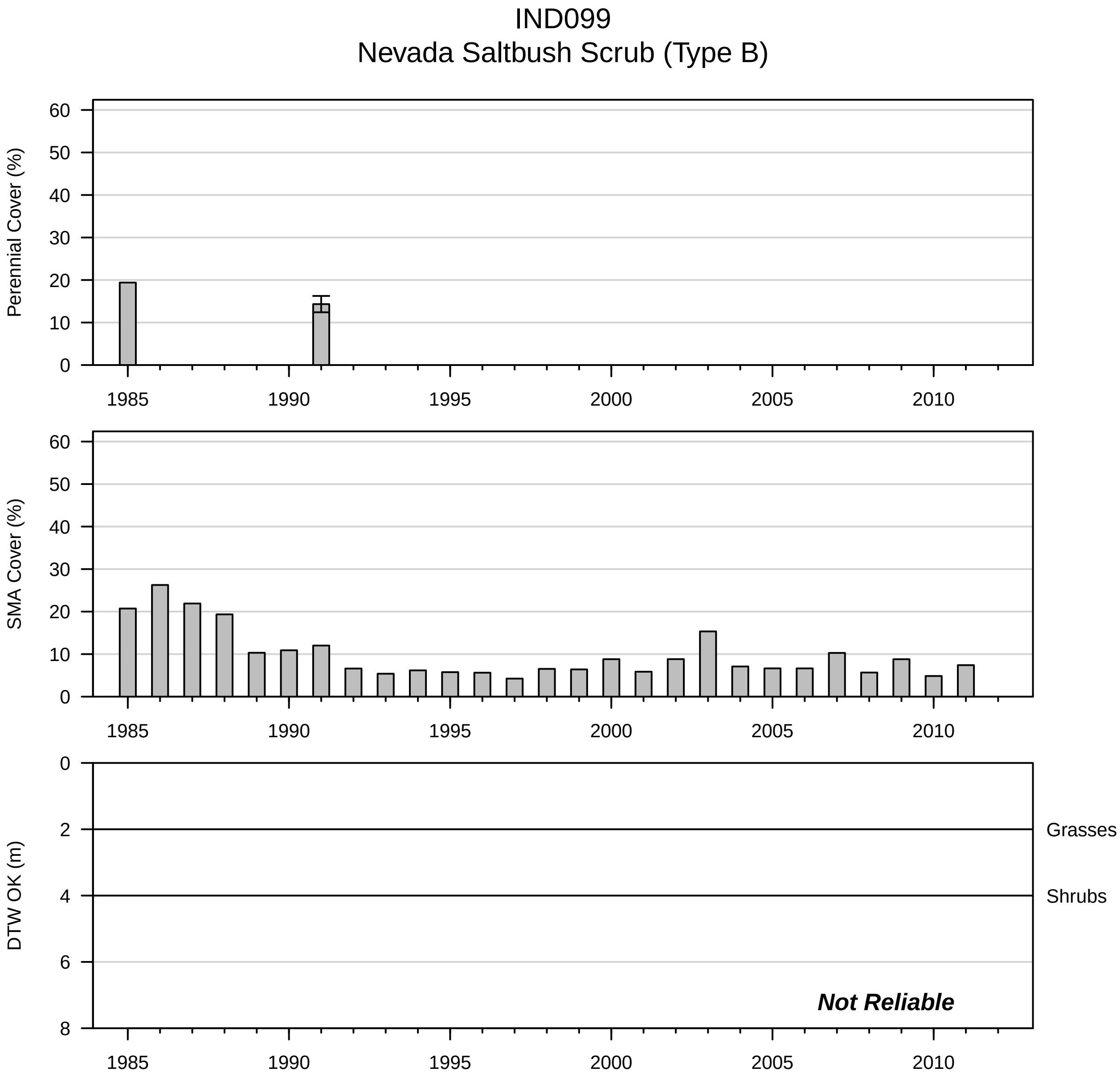


Figure 71: 1991 Control

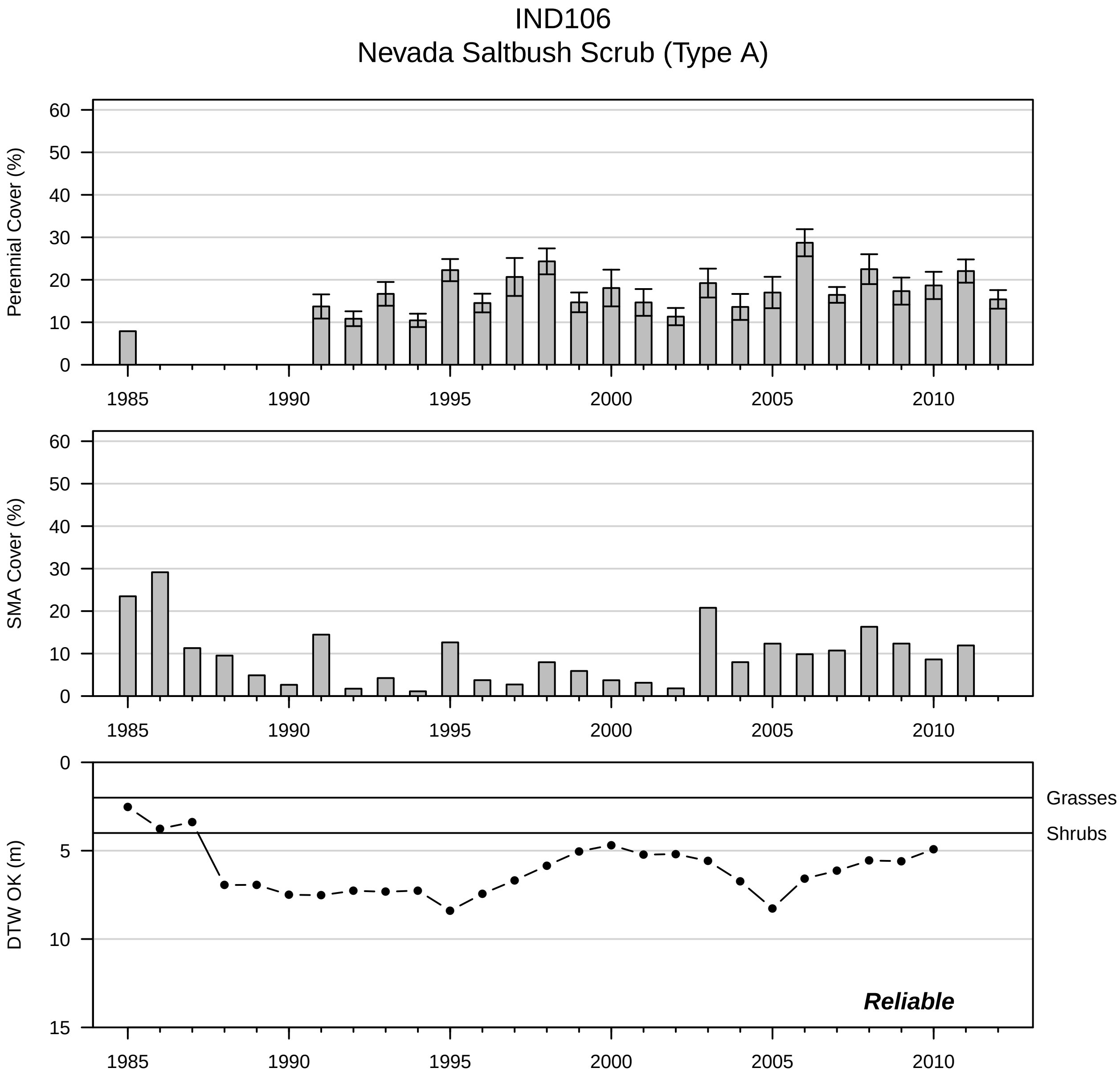


Figure 72: 2012 Wellfield

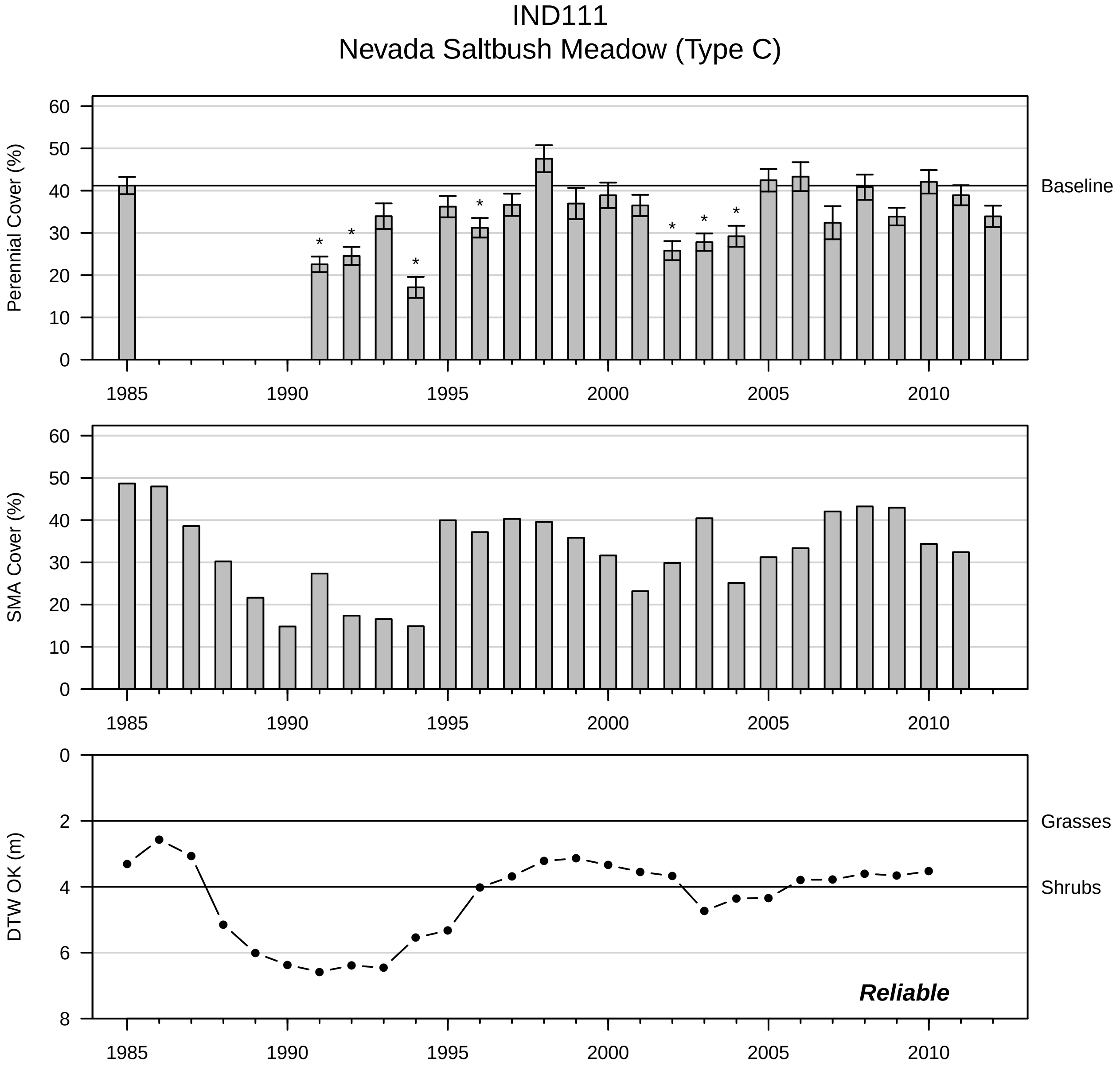


Figure 73: 2012 Wellfield

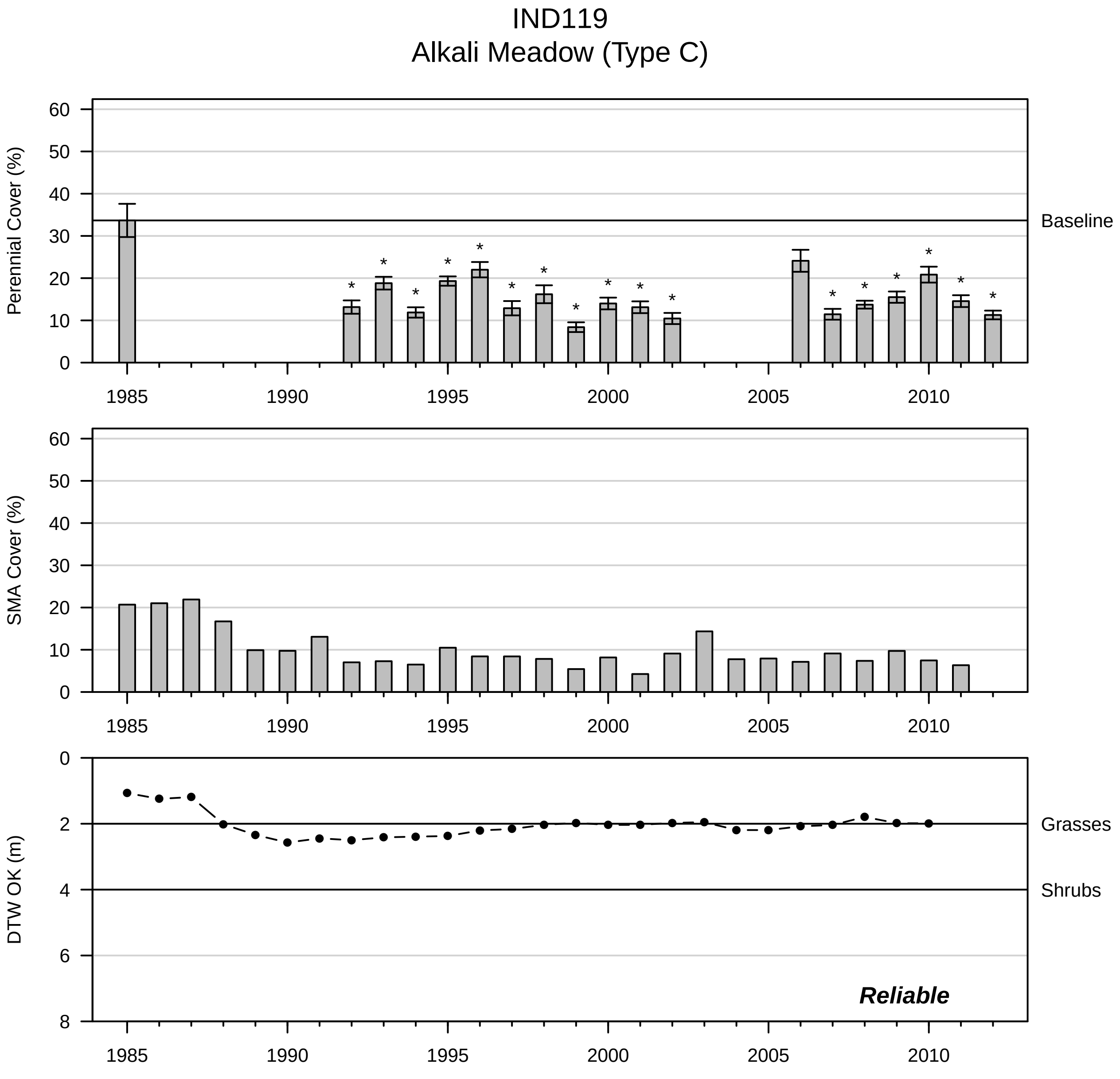


Figure 74: 2012 Control

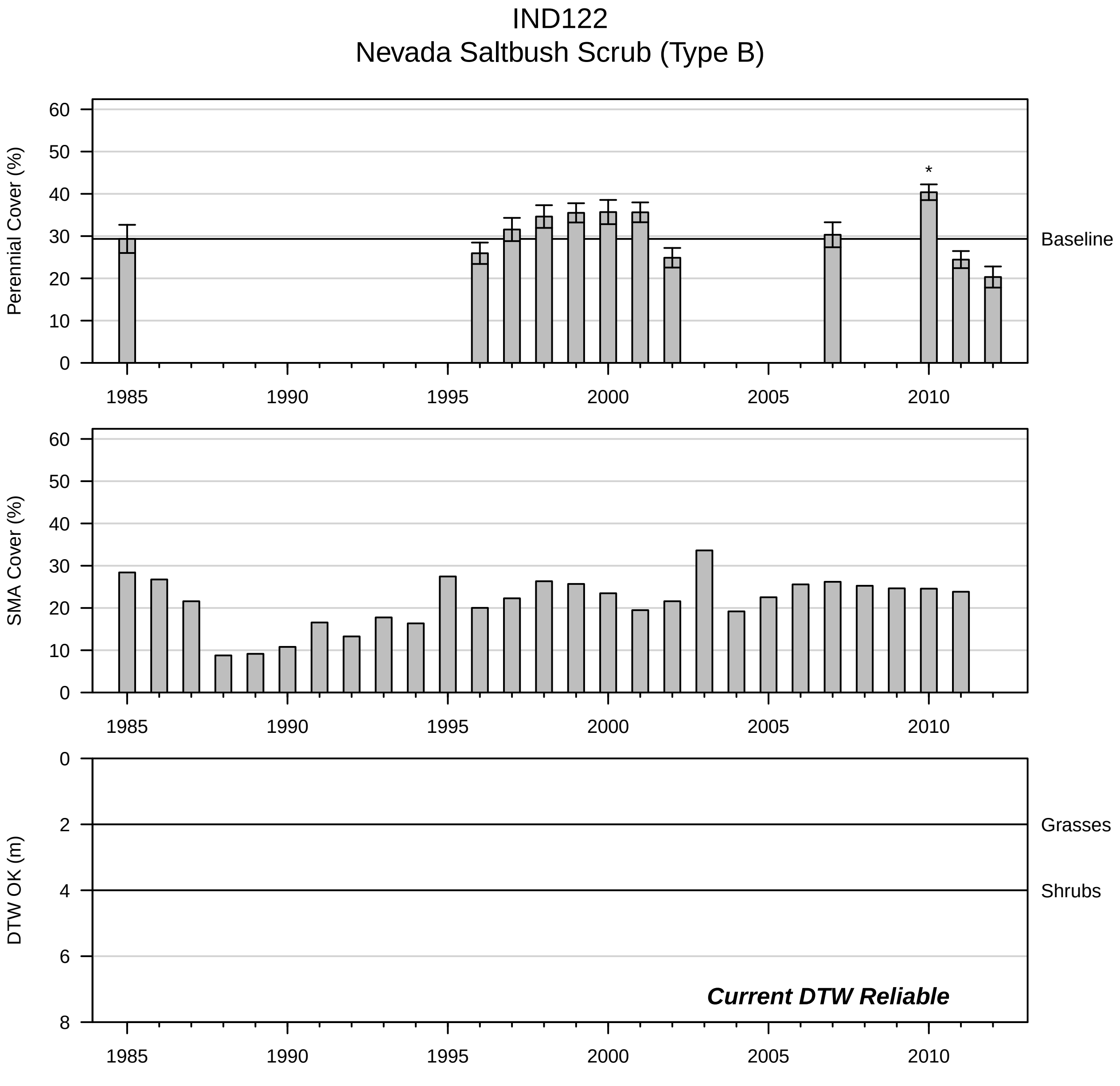


Figure 75: 2012 Control

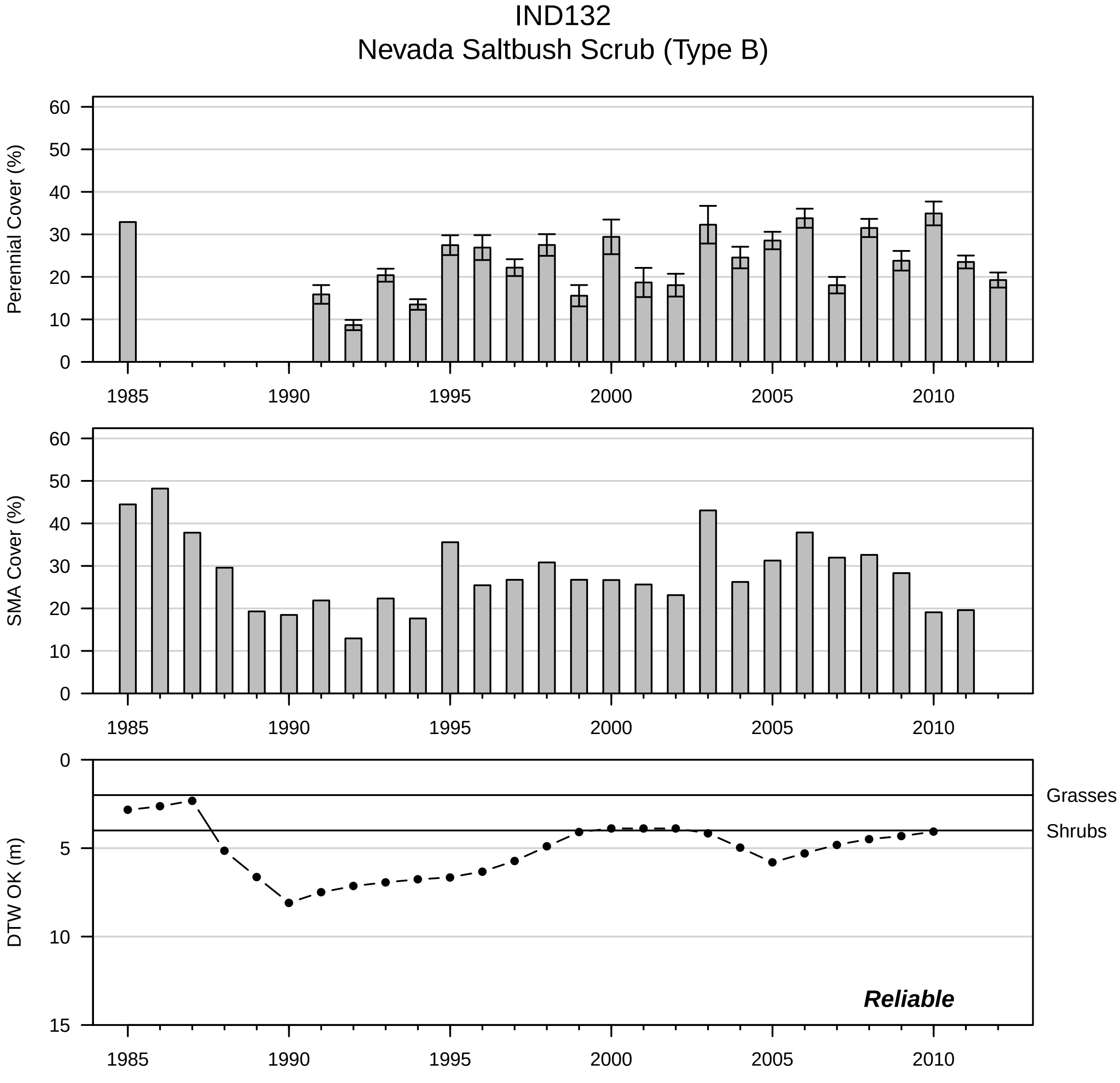


Figure 76: 2012 Wellfield

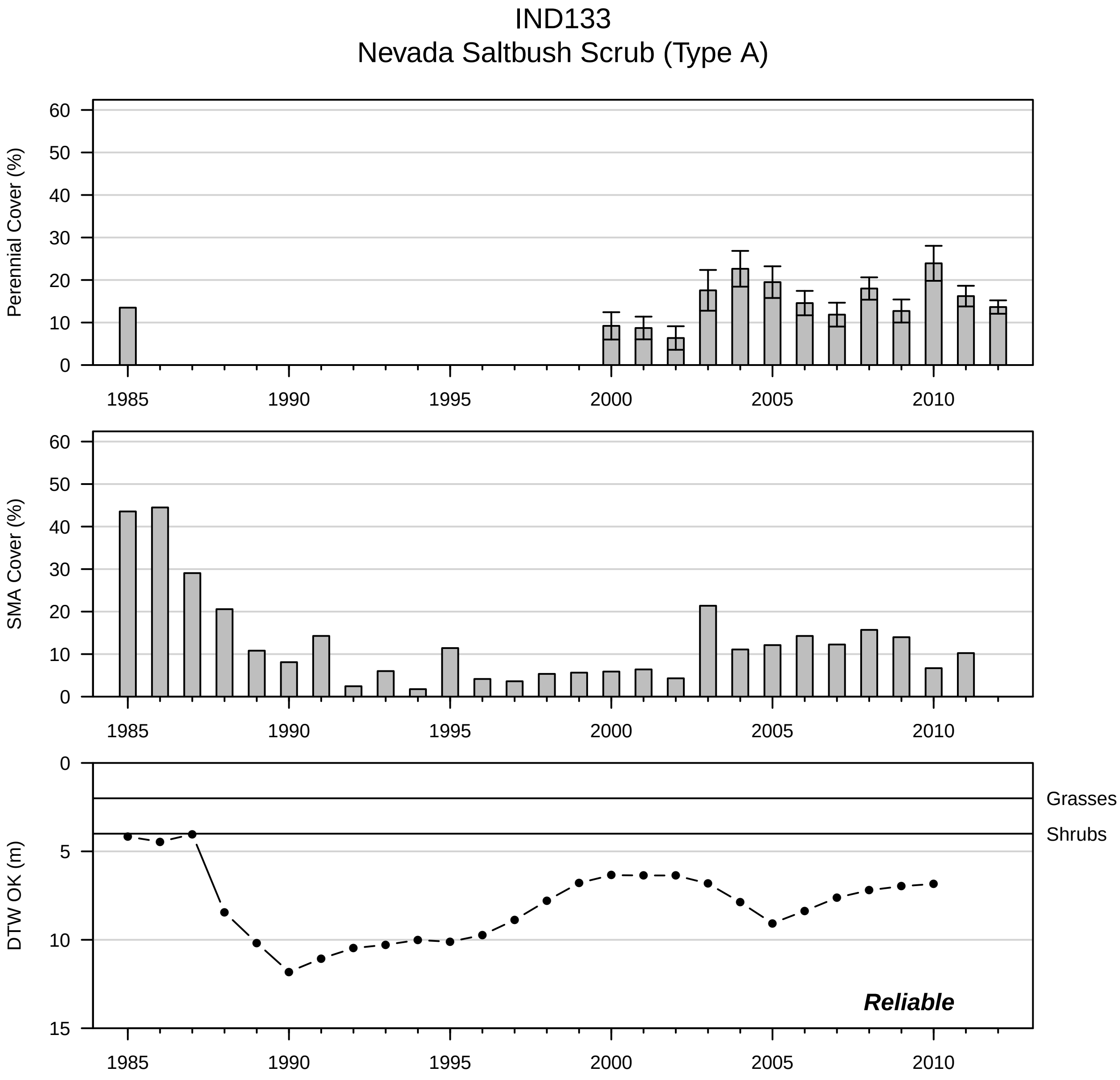


Figure 77: 2012 Wellfield

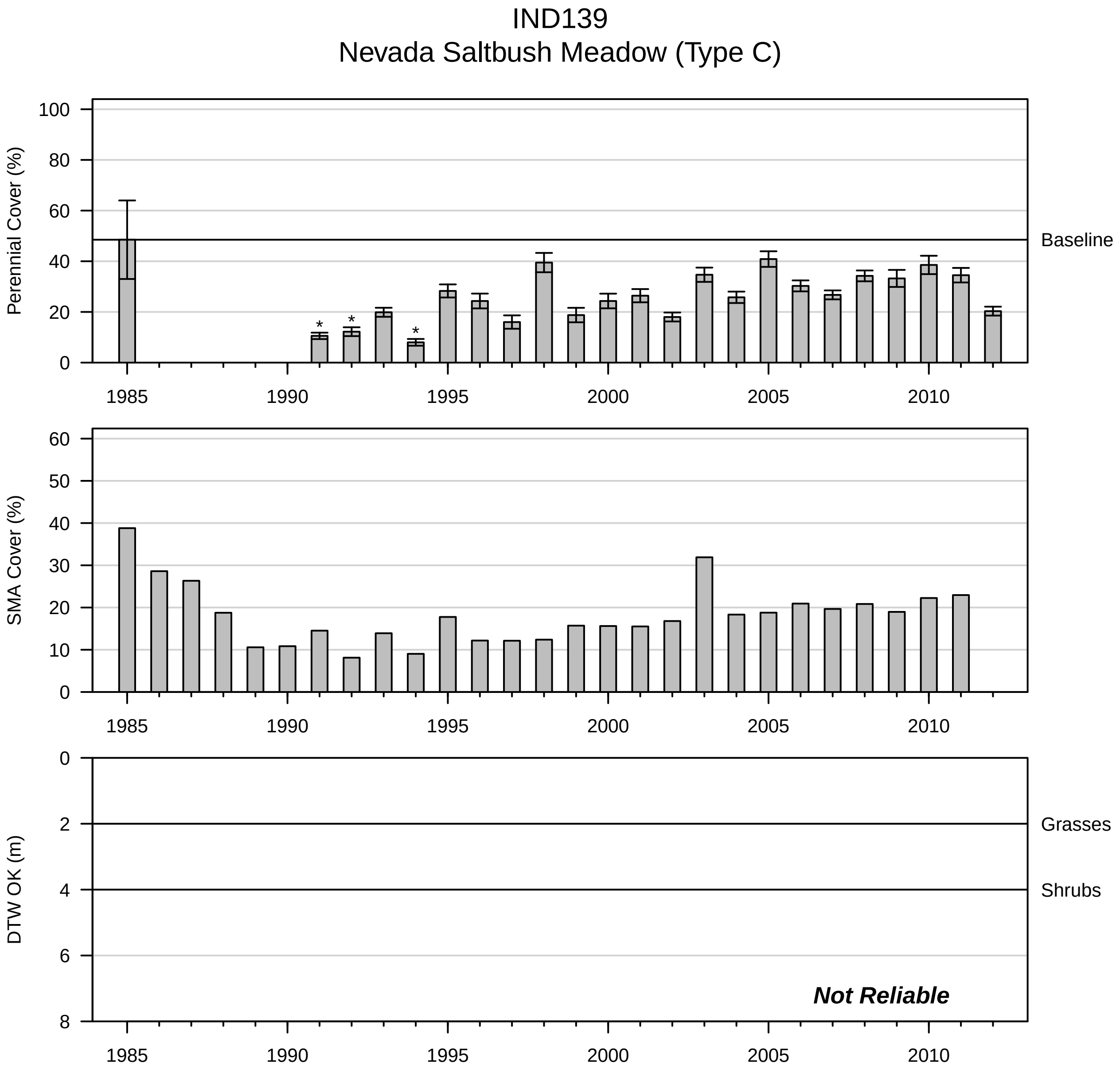


Figure 78: 2012 Wellfield

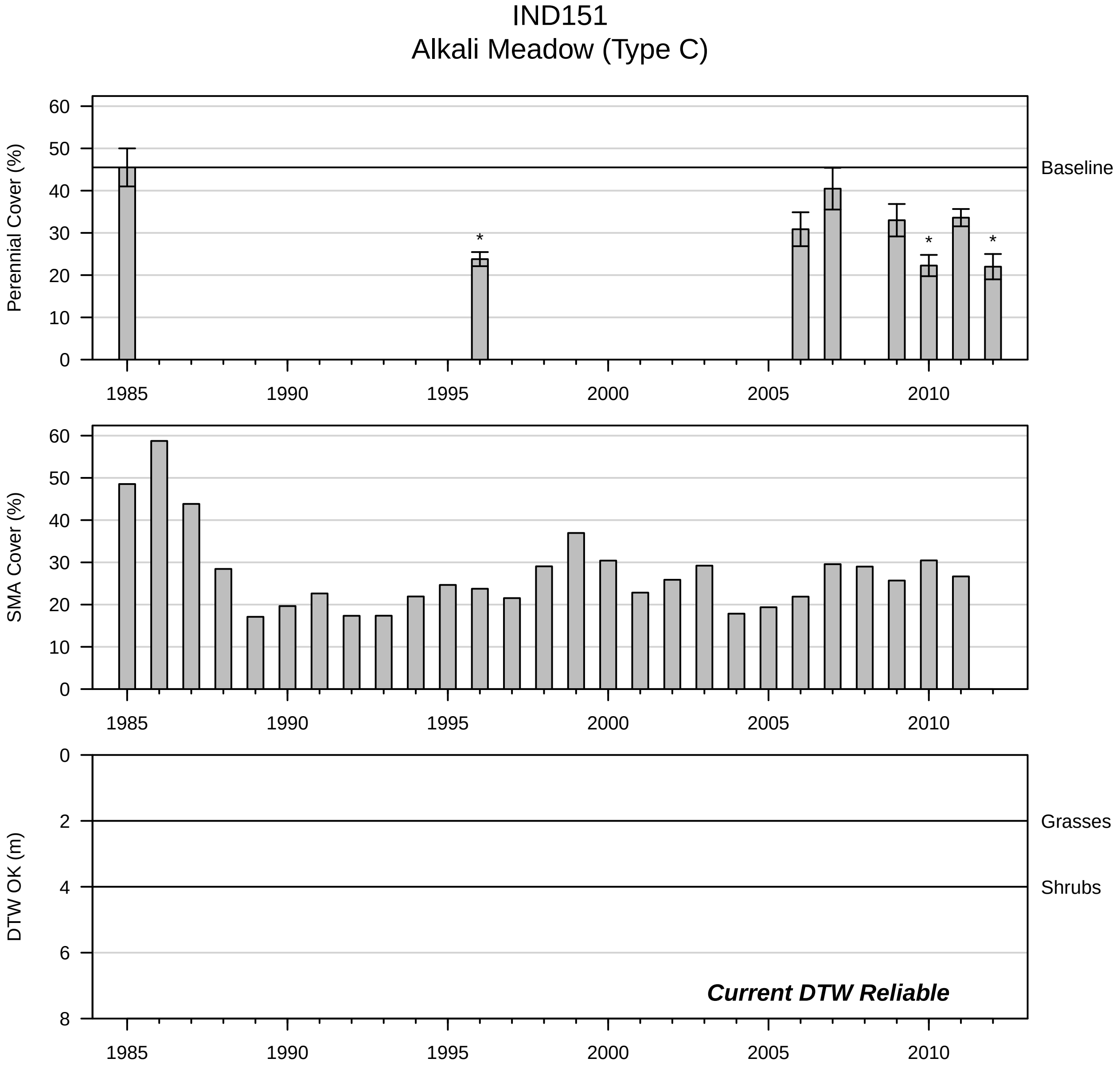


Figure 79: 2012 Control

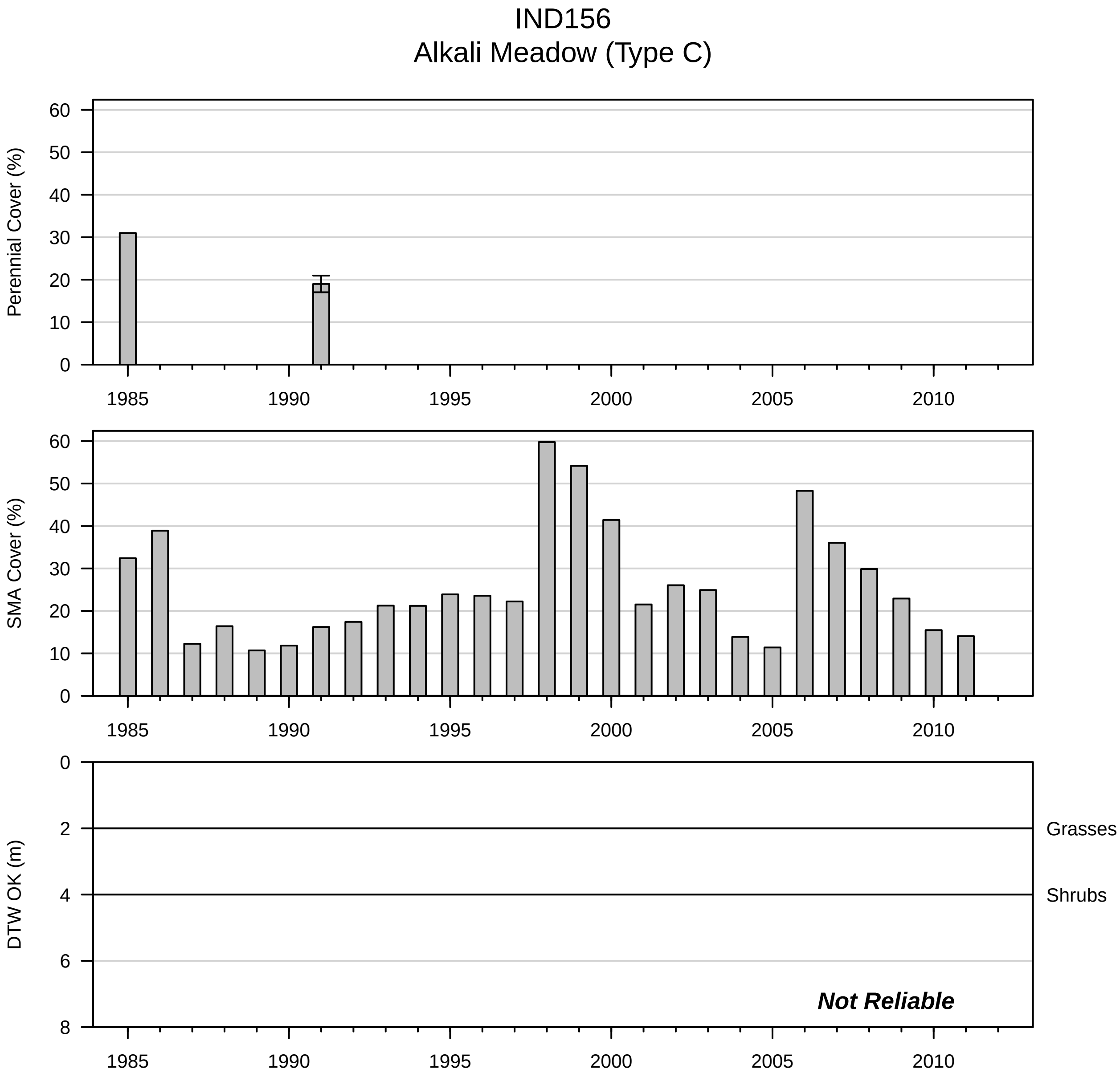


Figure 80: 1991 Control

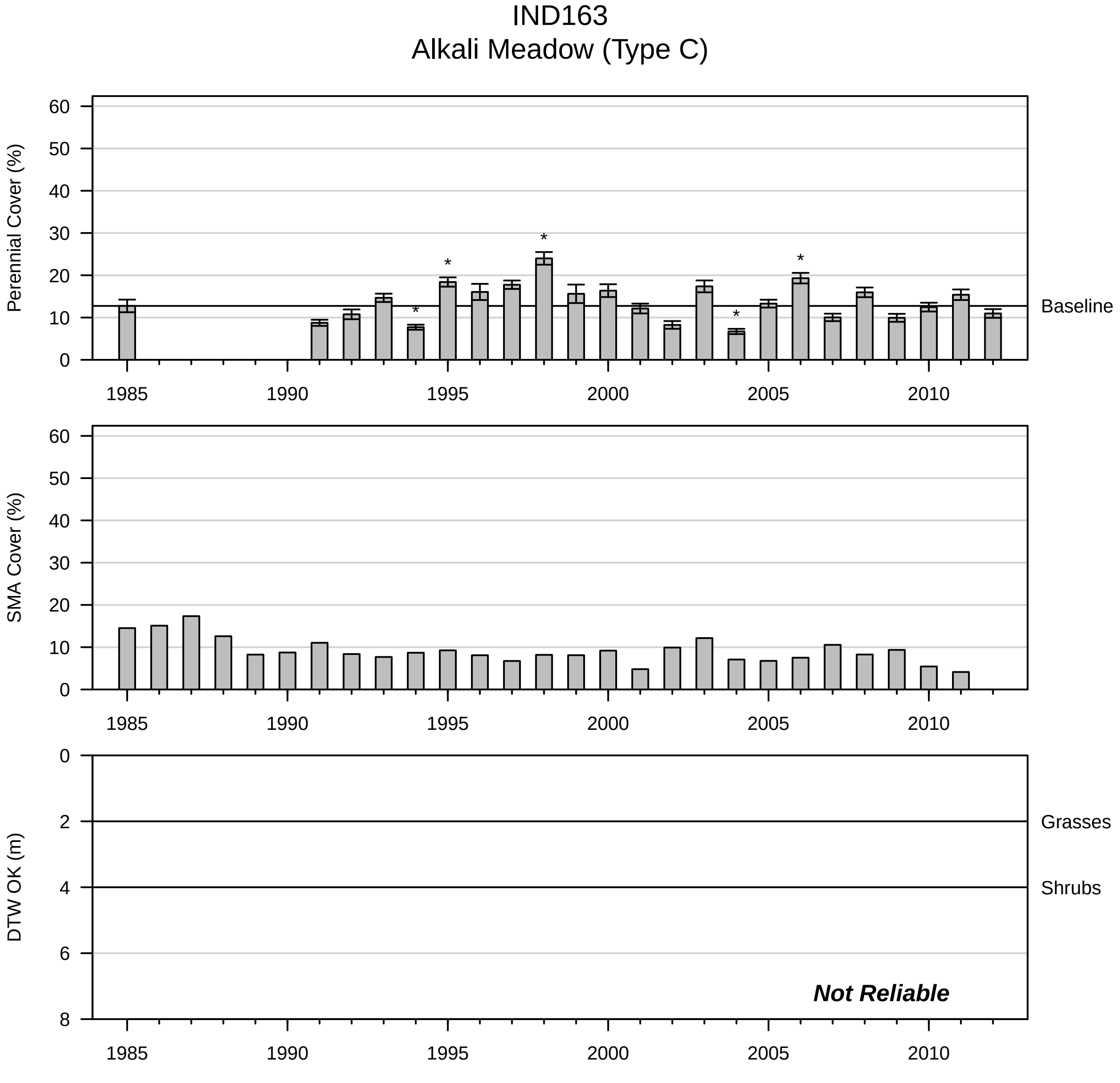


Figure 81: 2012 Control

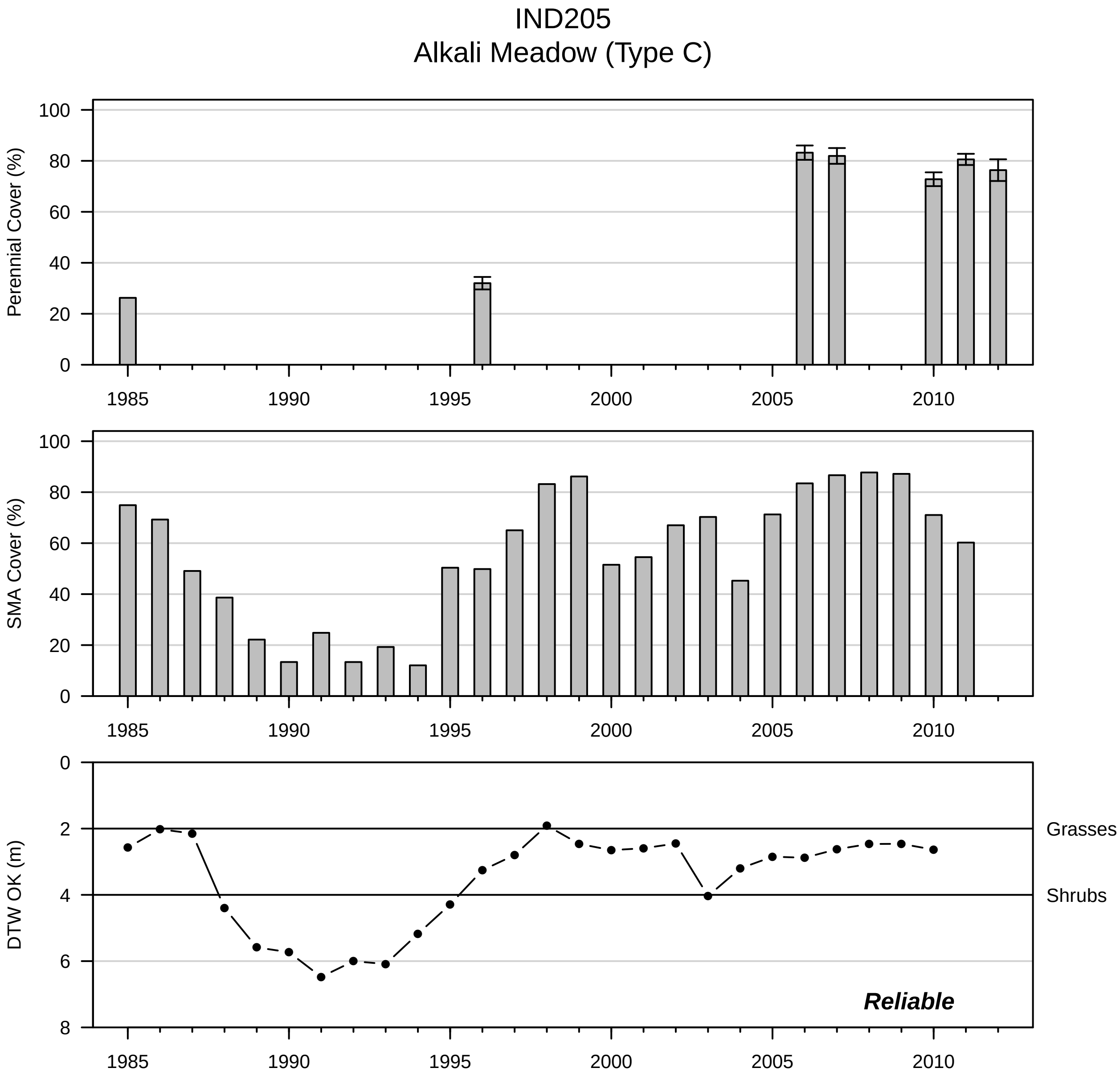


Figure 82: 2012 Wellfield

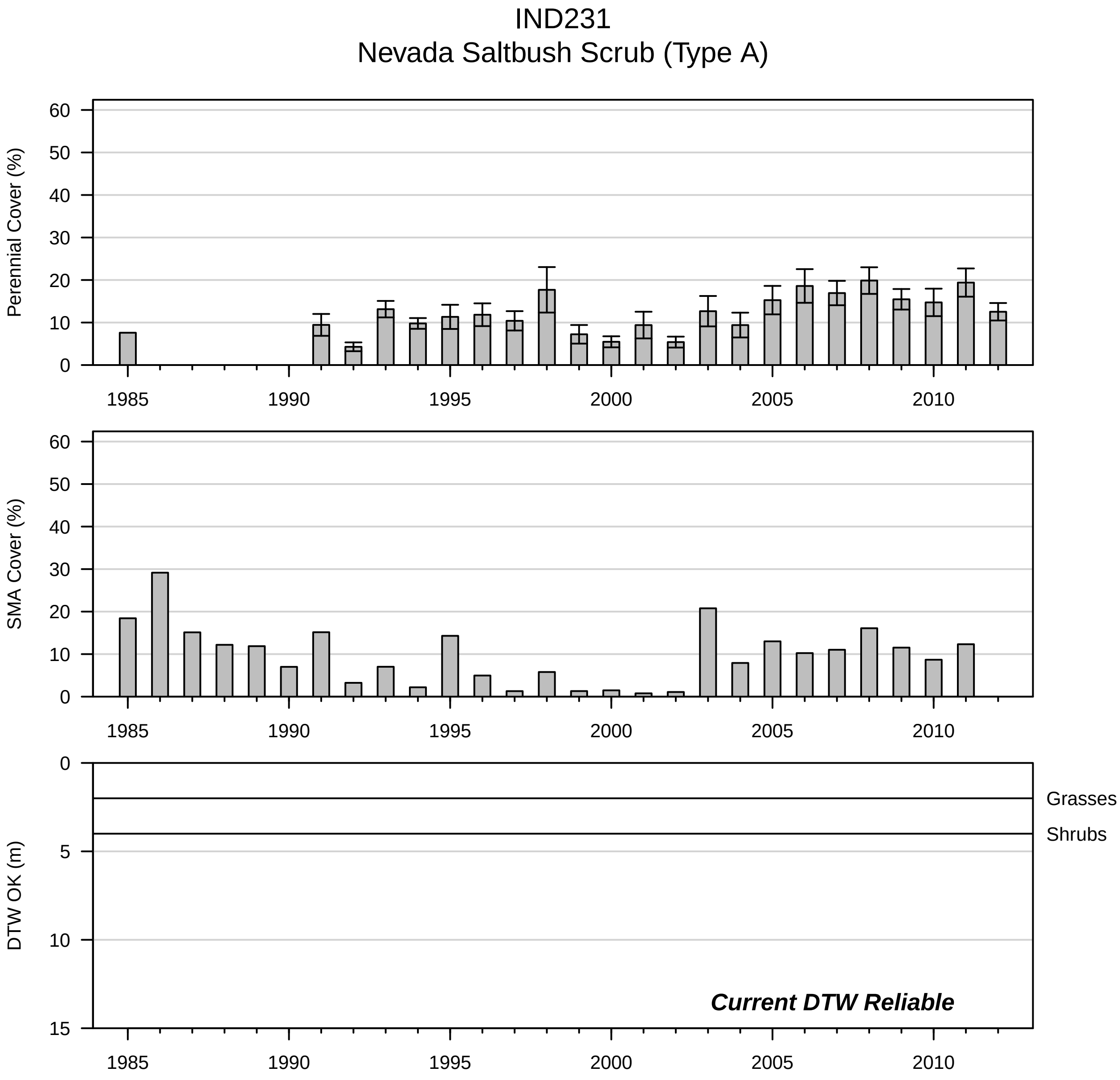


Figure 83: 2012 Wellfield

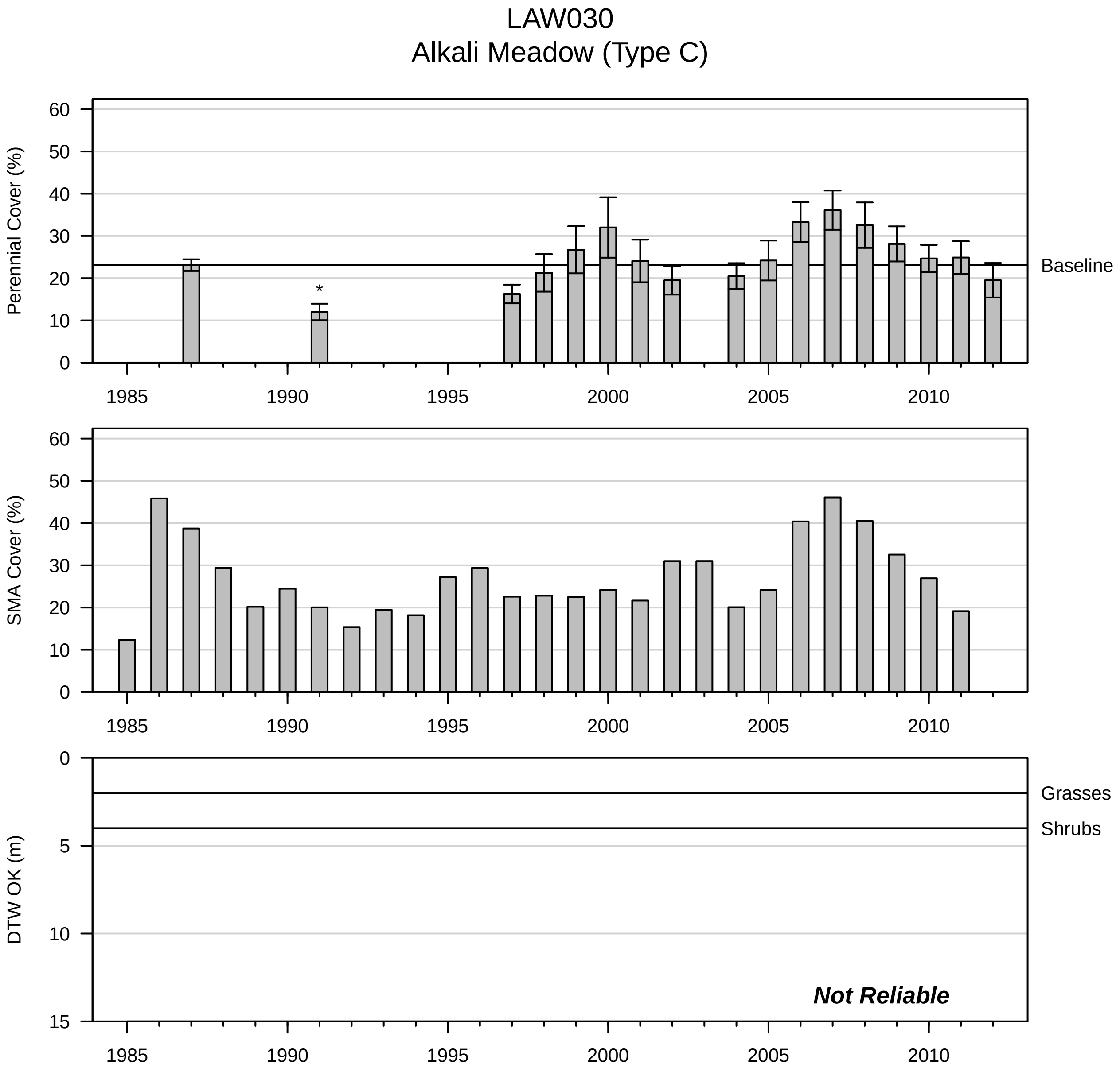


Figure 84: 2012 Wellfield

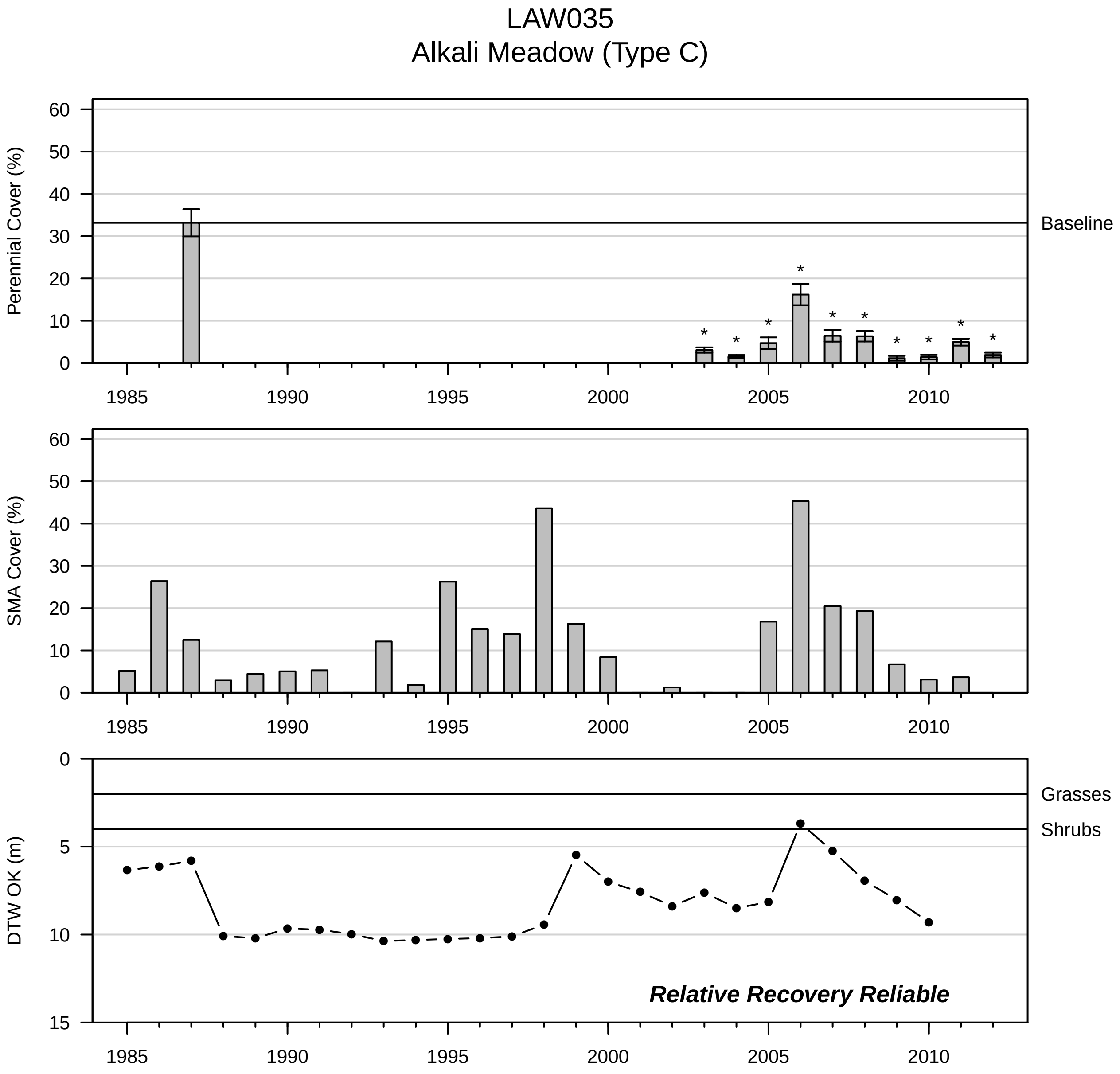


Figure 85: 2012 Wellfield

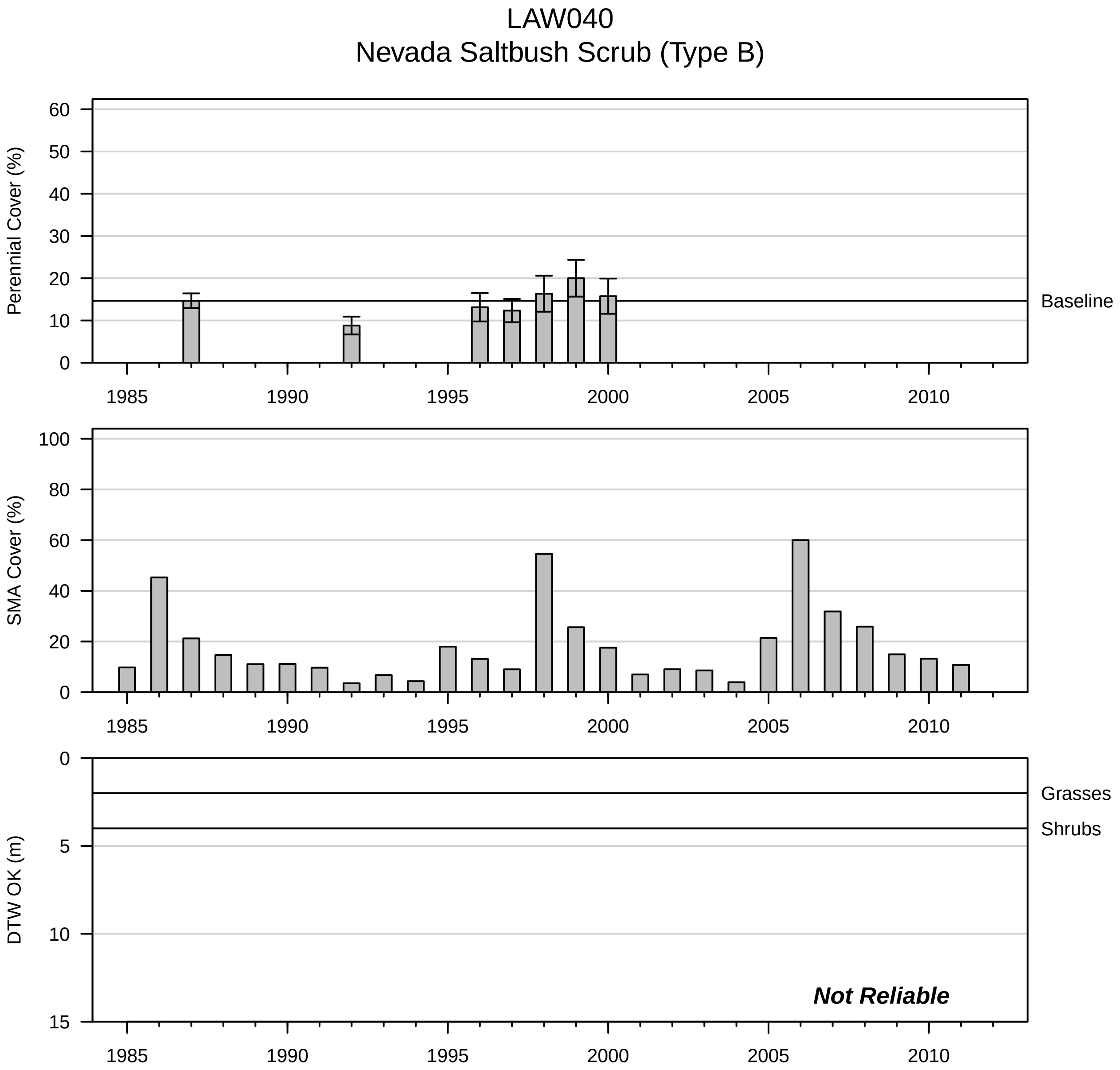


Figure 86: 2000 Wellfield

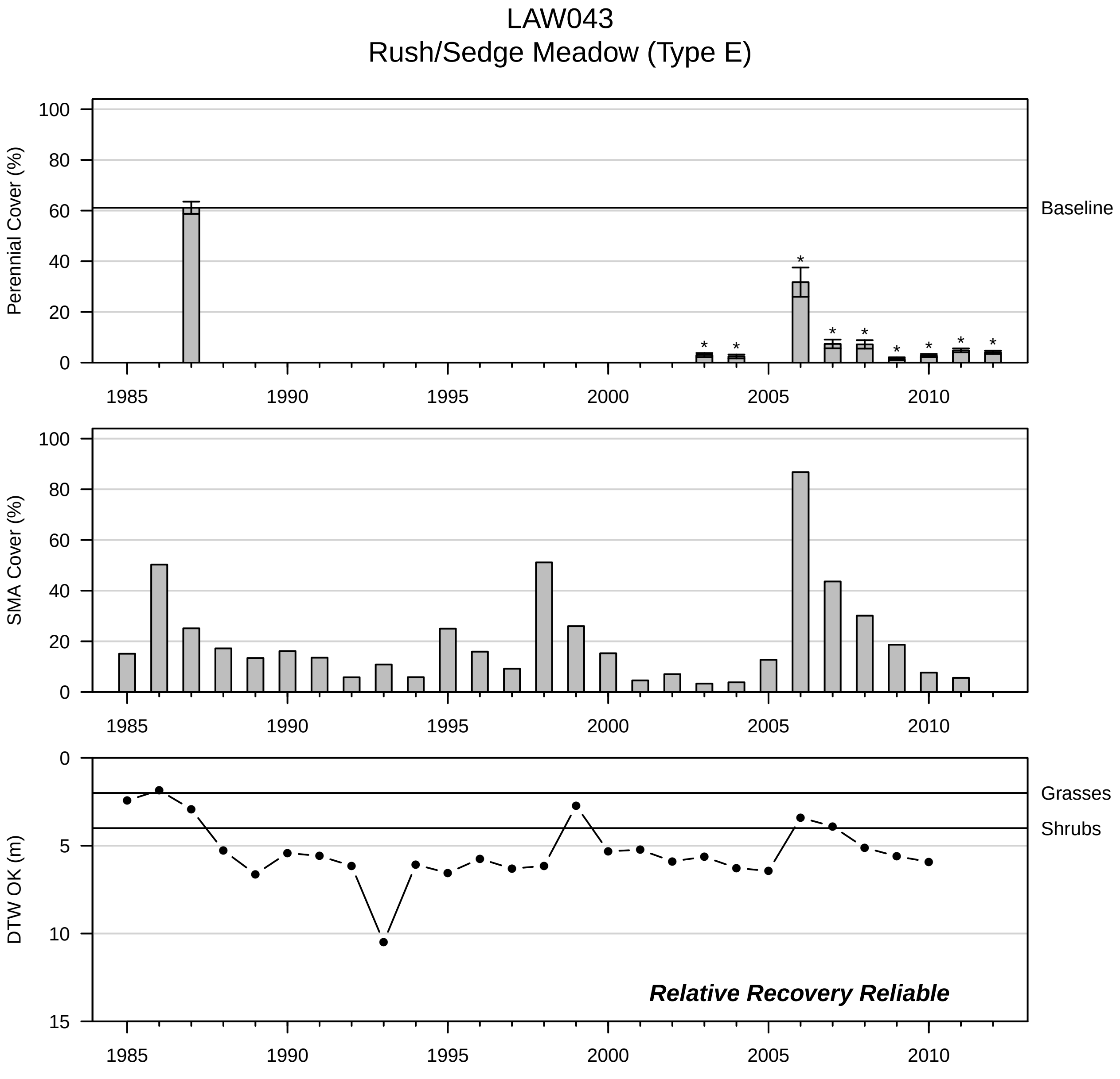


Figure 87: 2012 Wellfield

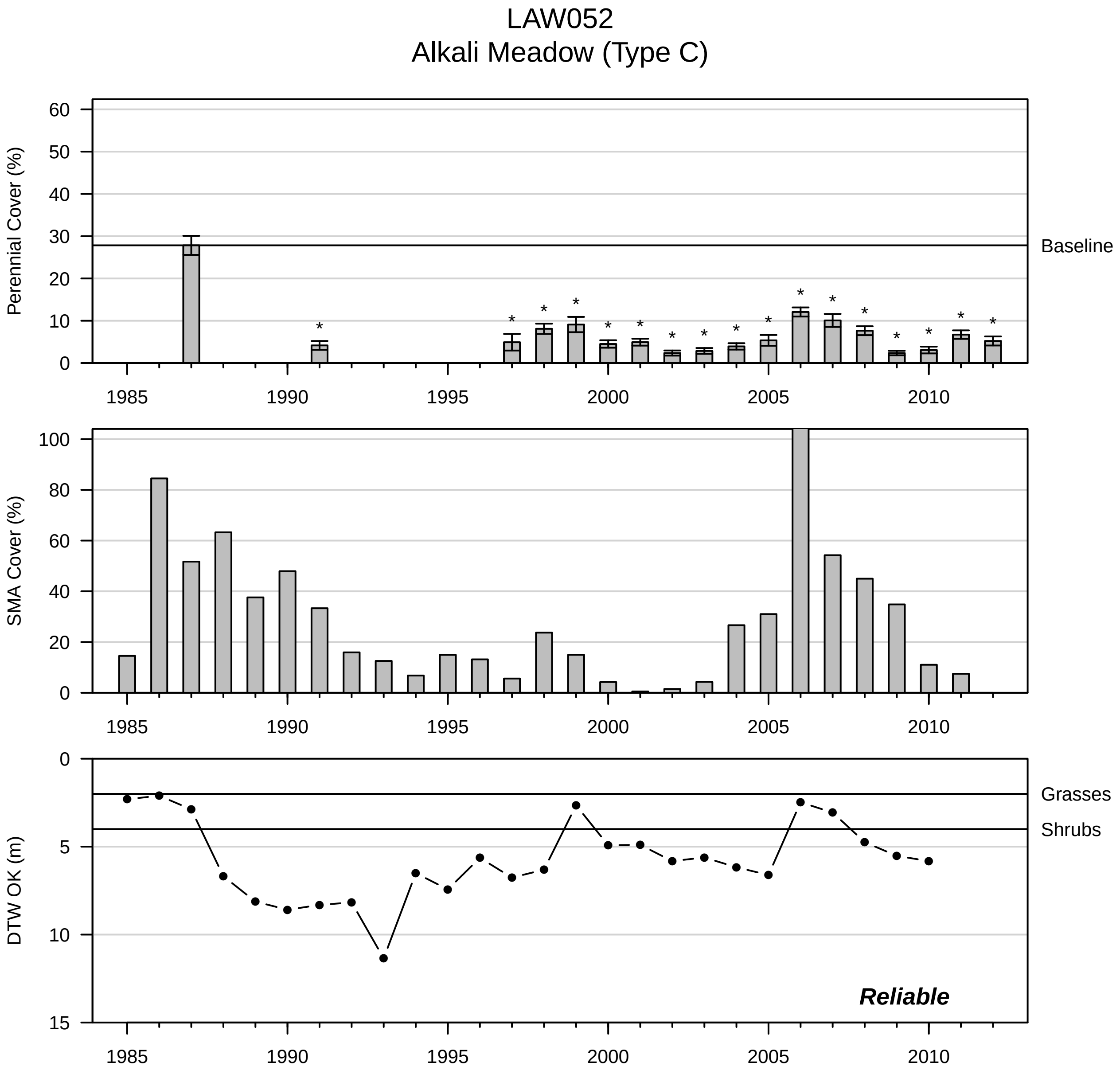


Figure 88: 2012 Wellfield

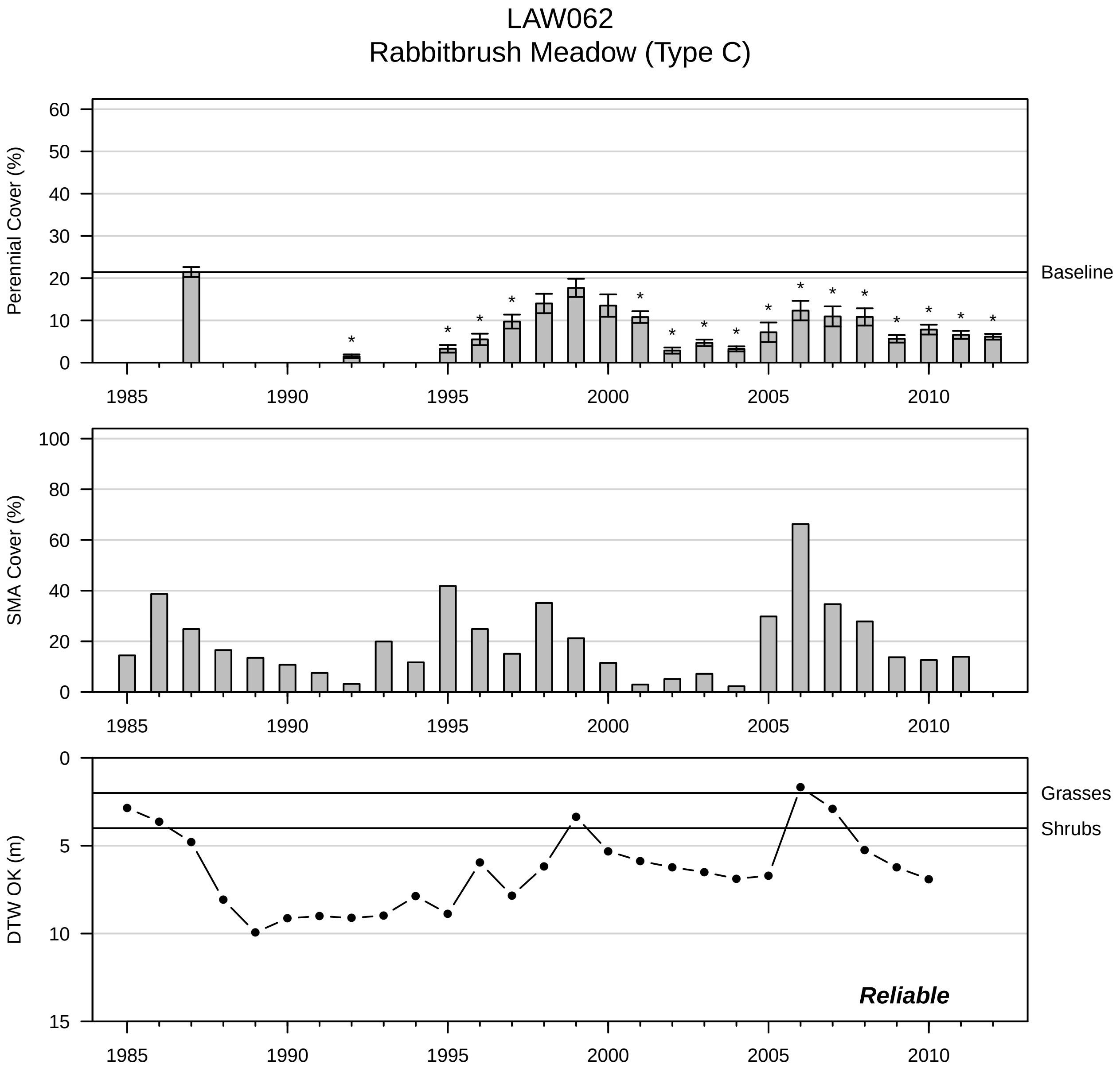


Figure 89: 2012 Wellfield

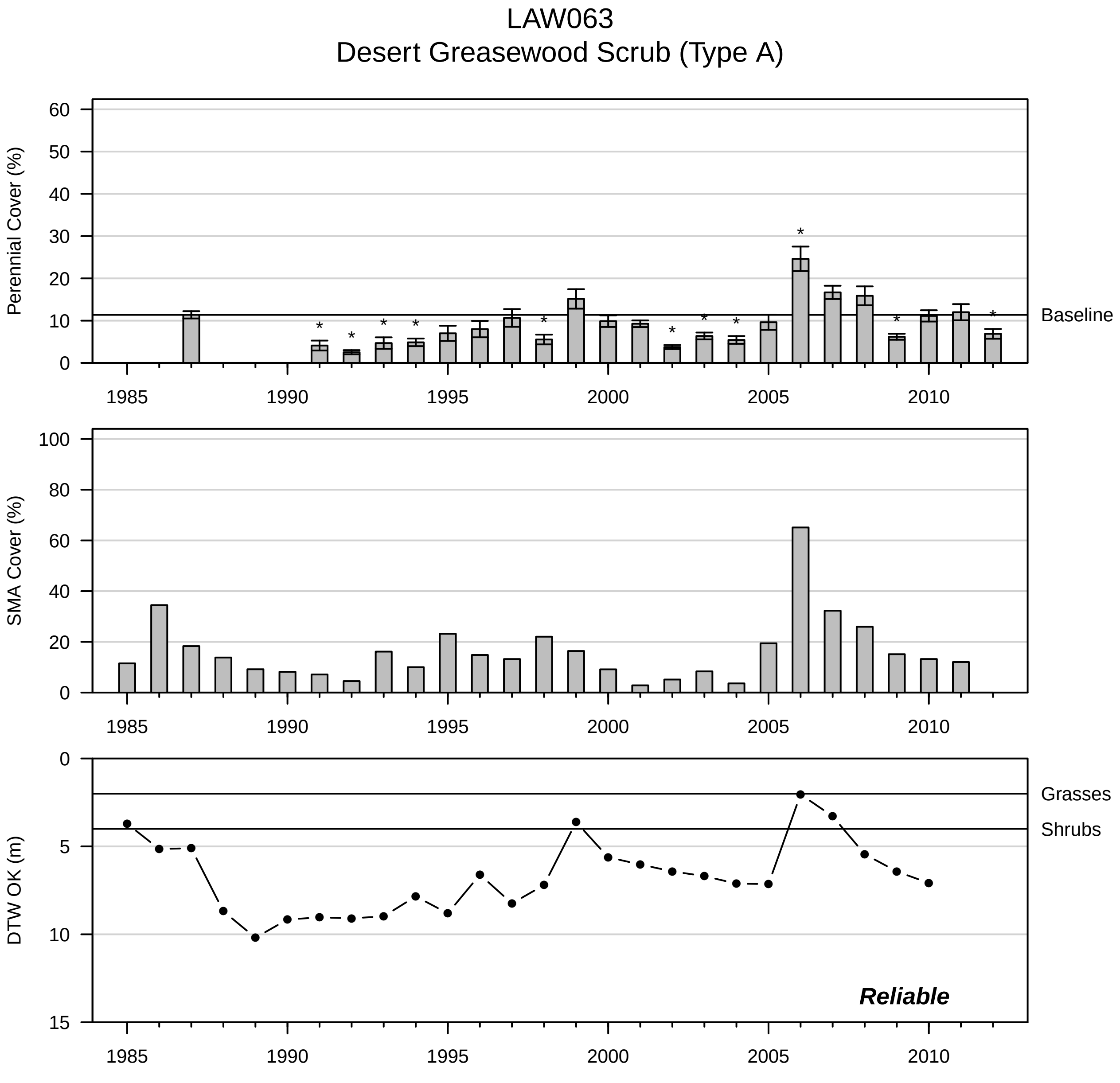


Figure 90: 2012 Wellfield

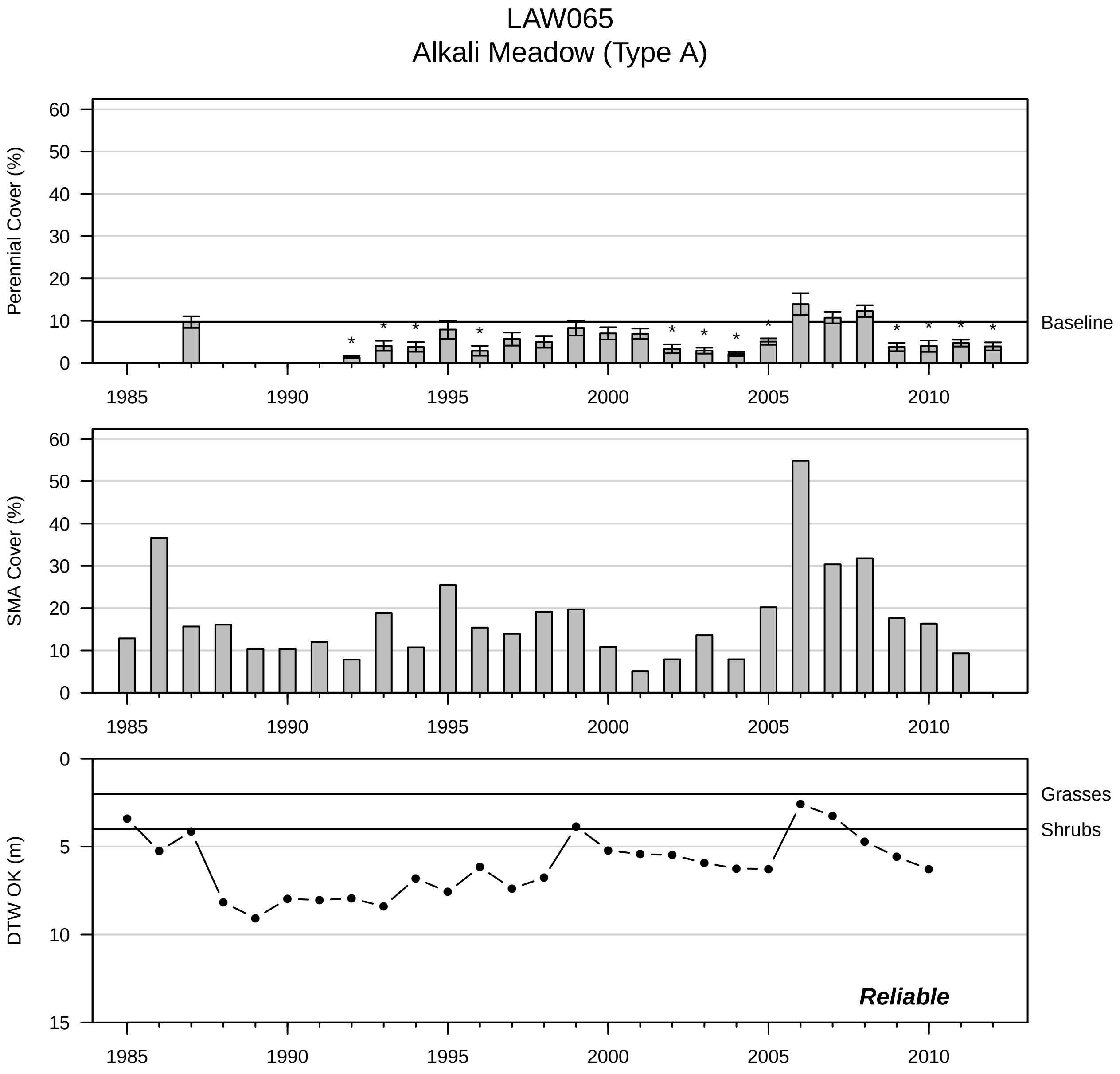
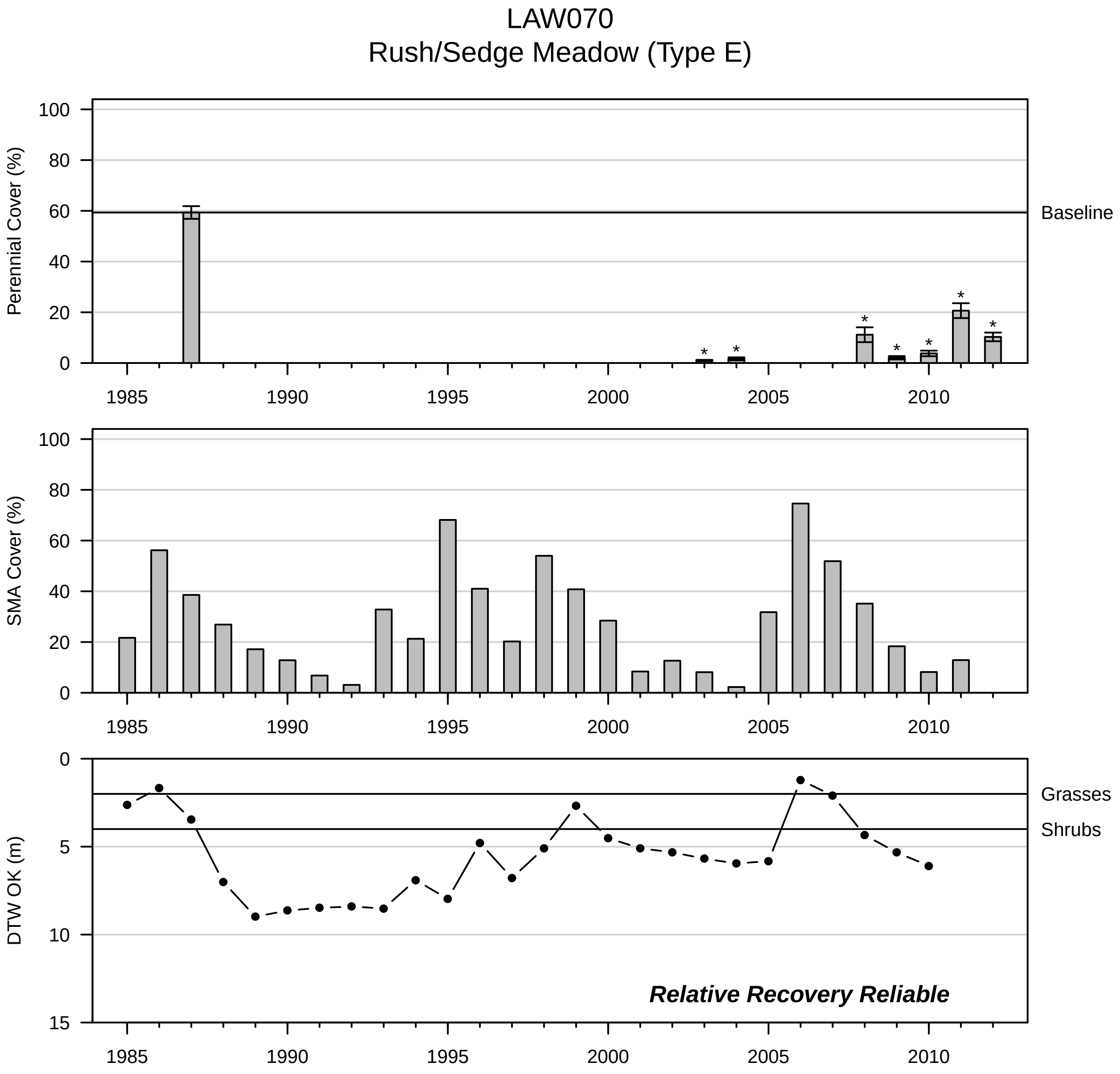


Figure 91: 2012 Wellfield



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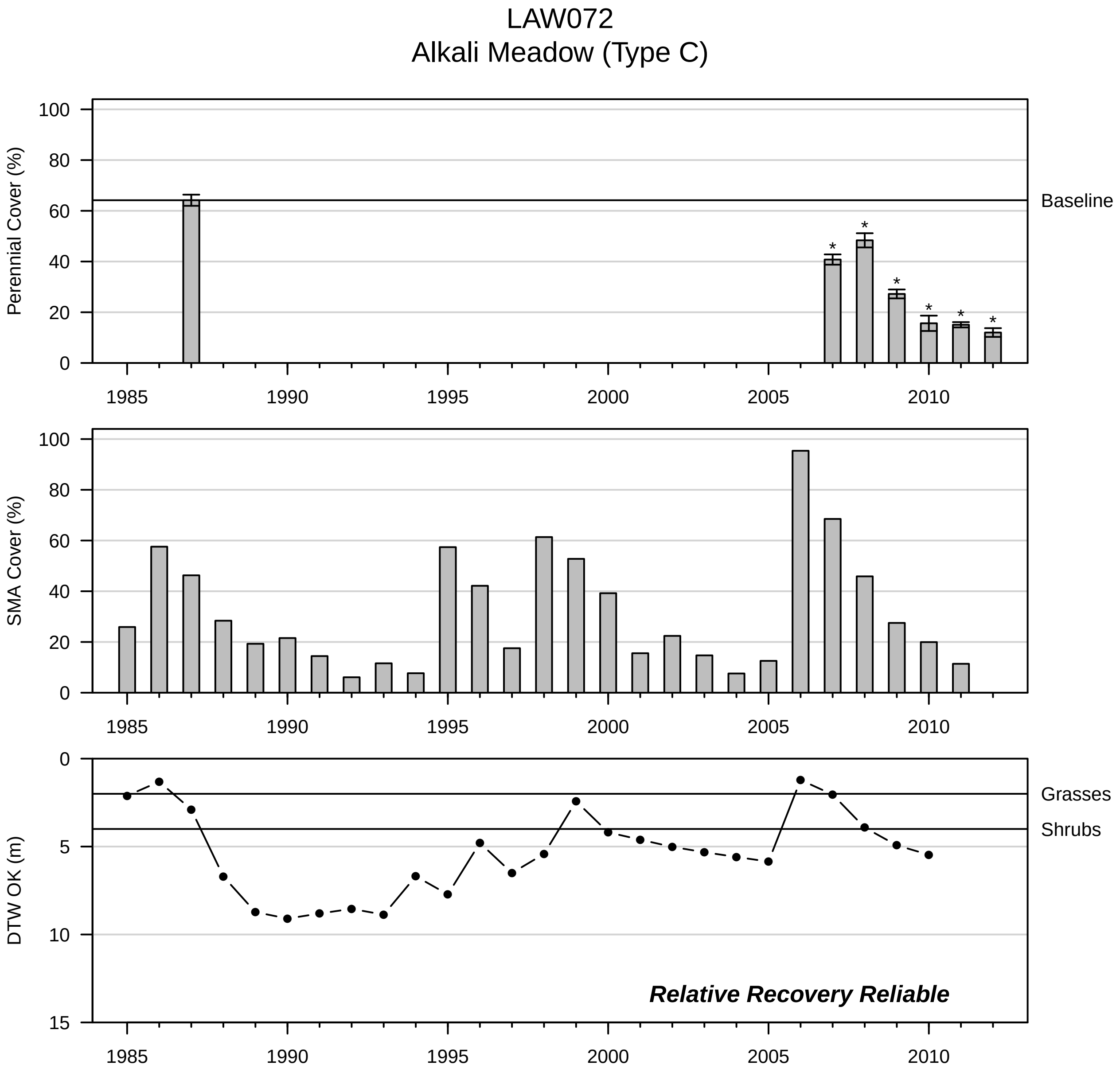


Figure 93: 2012 Wellfield

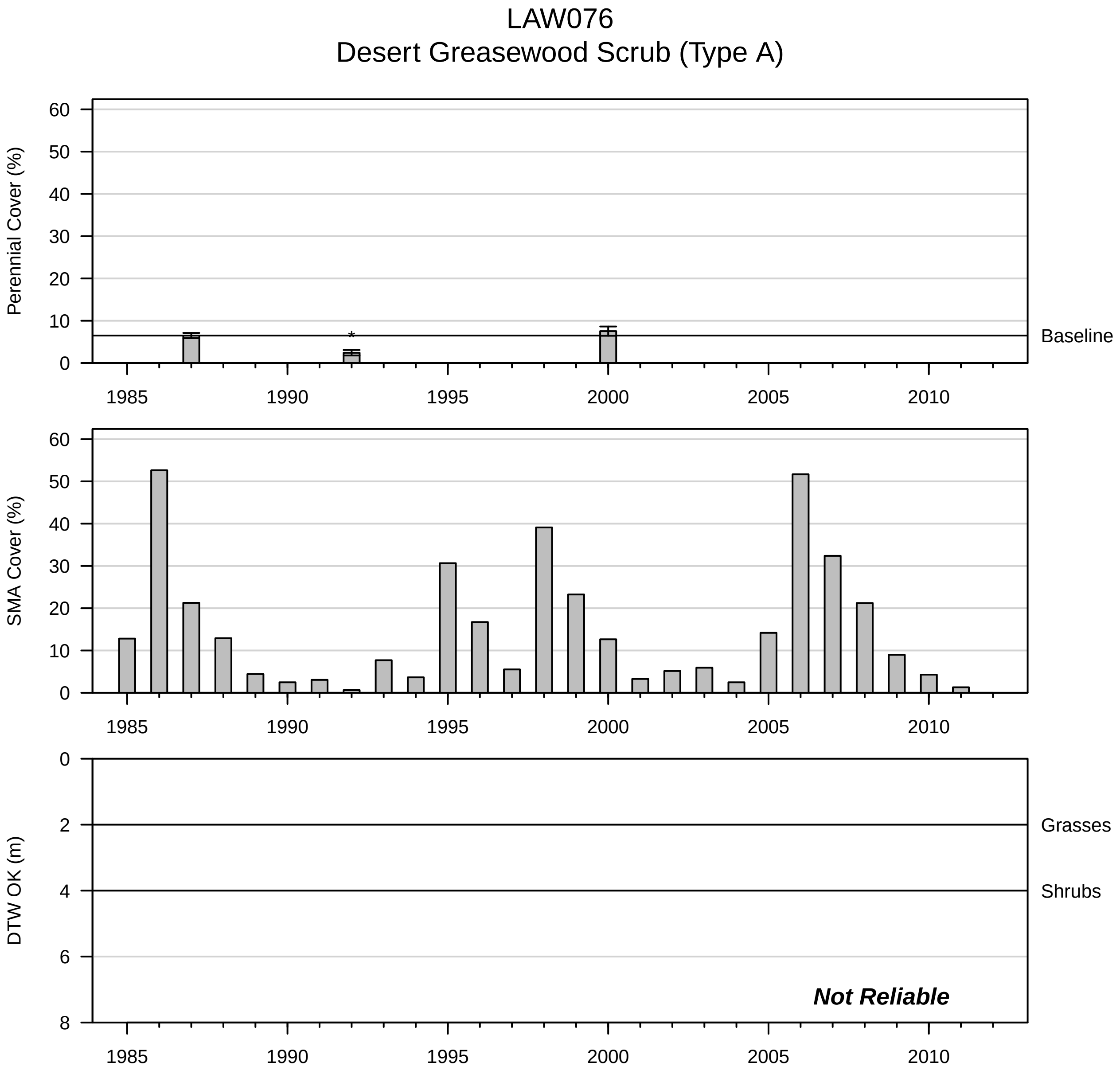


Figure 94: 2000 Wellfield

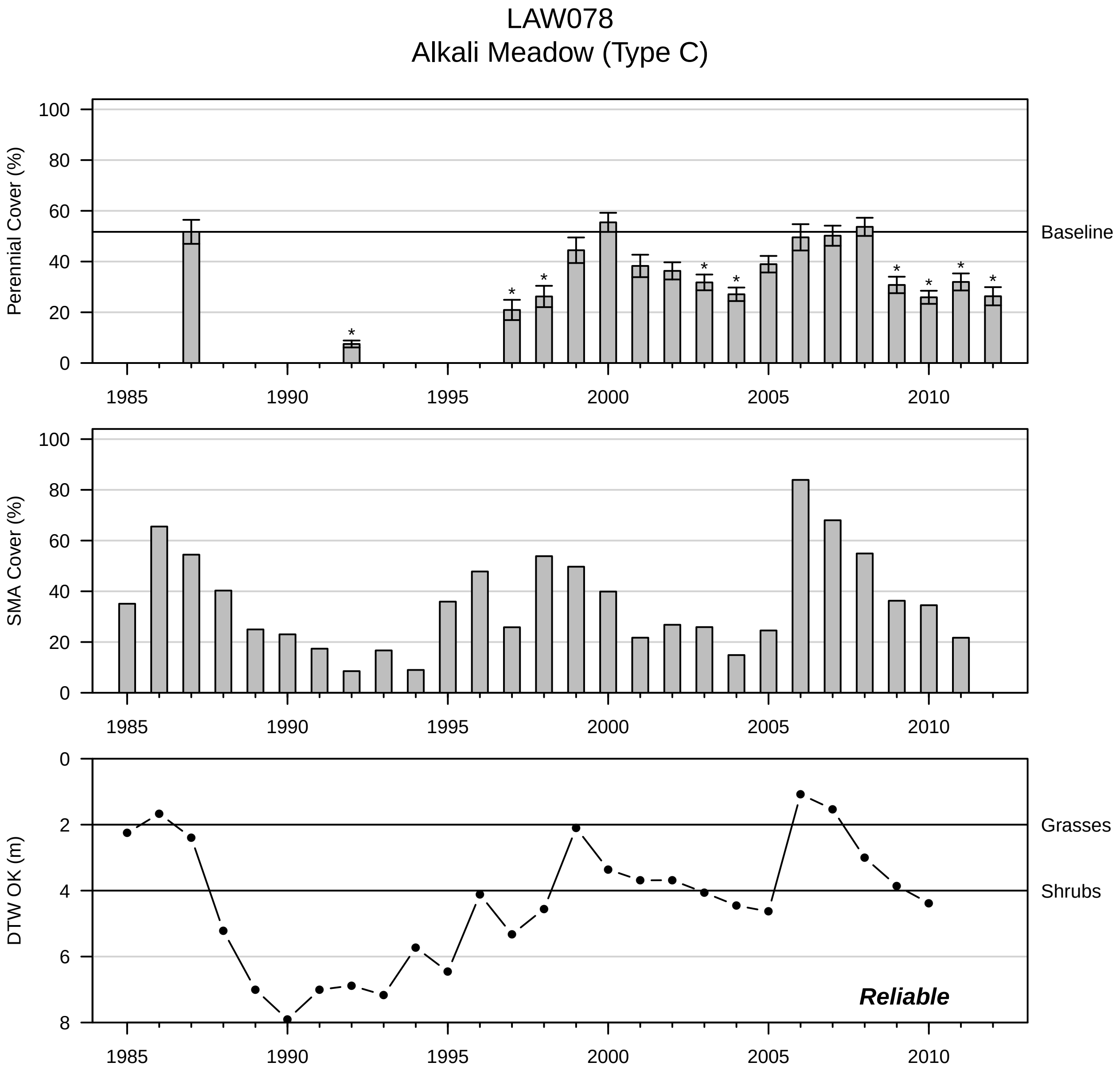


Figure 95: 2012 Wellfield

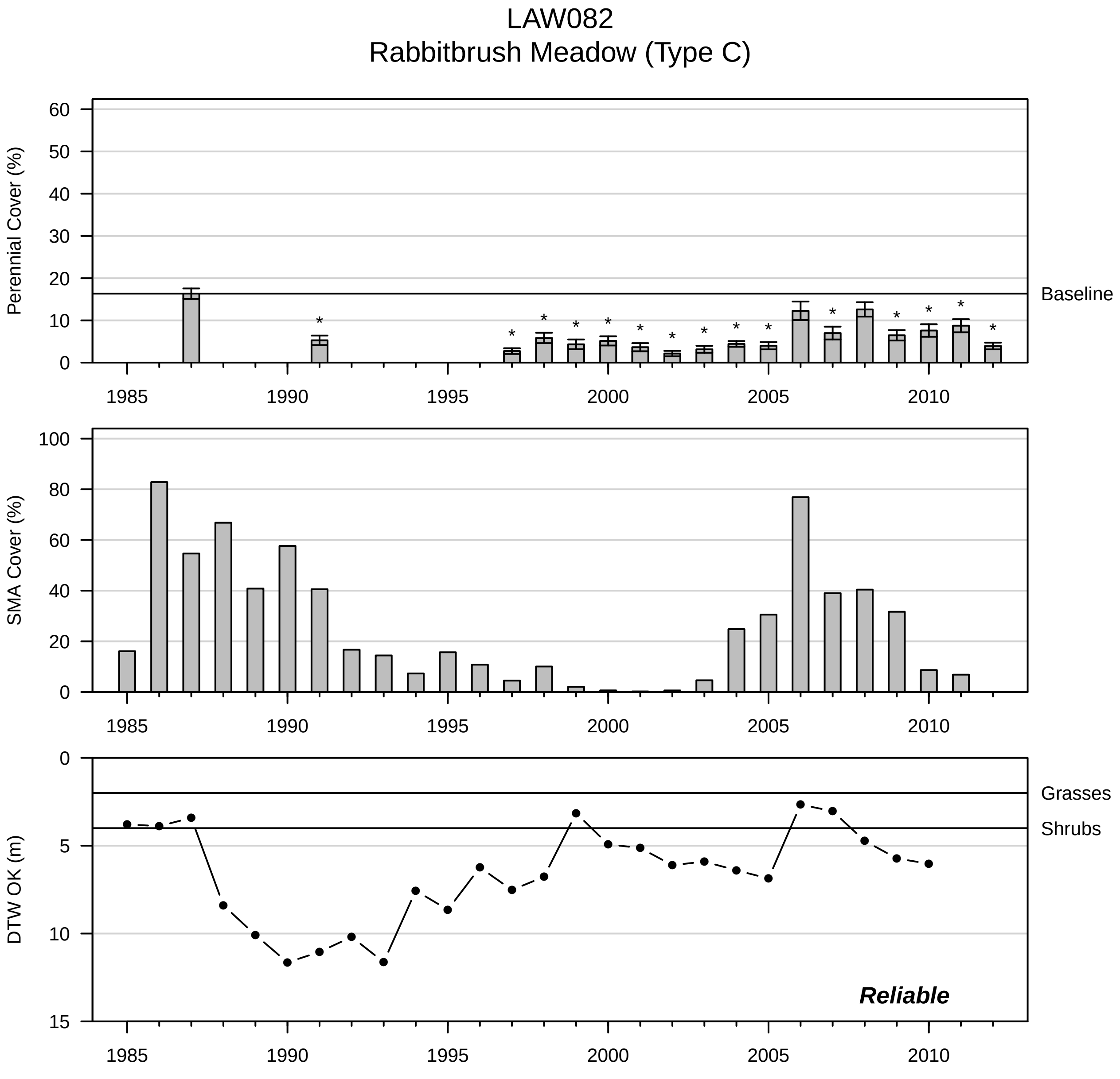
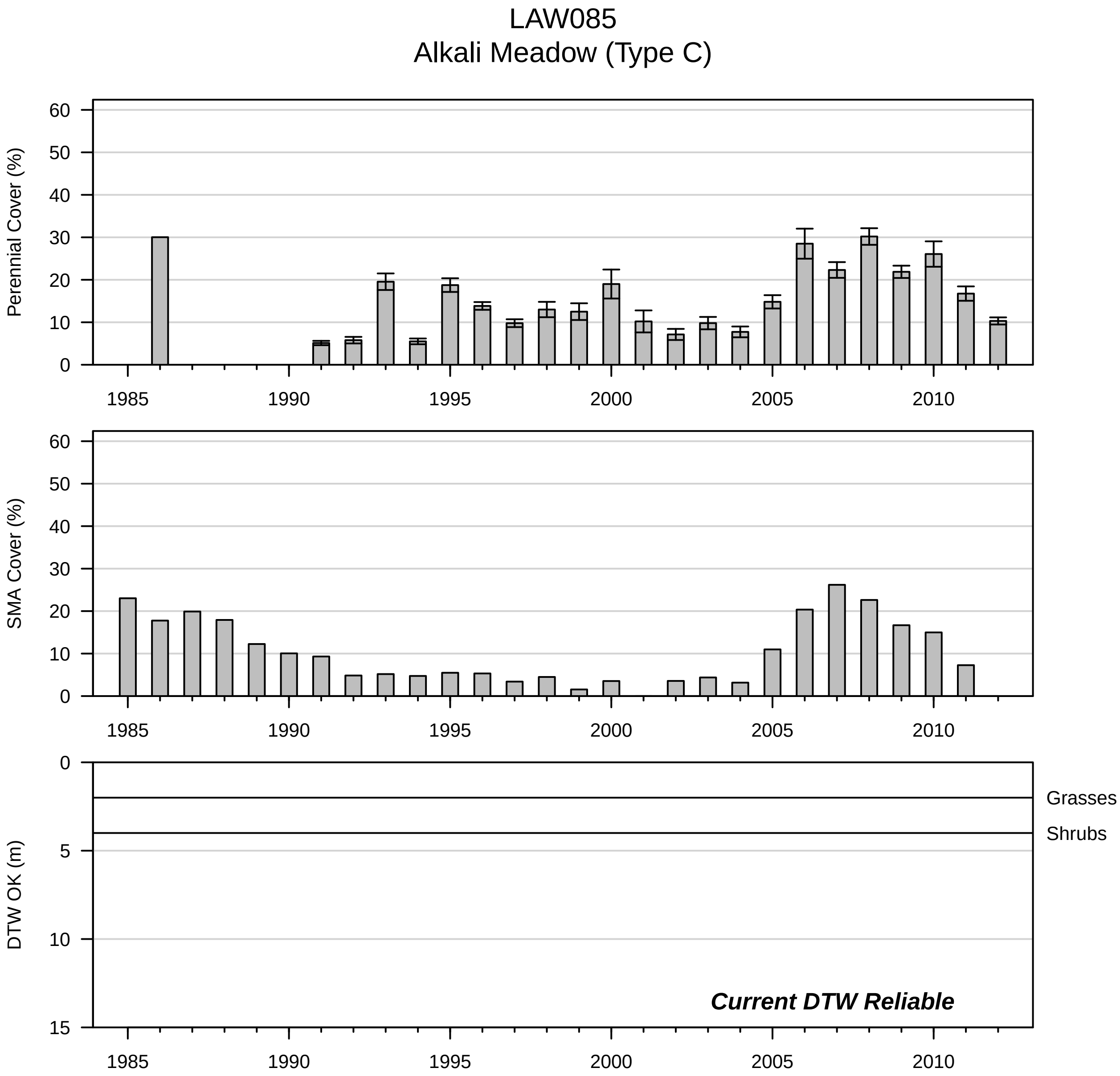


Figure 96: 2012 Wellfield



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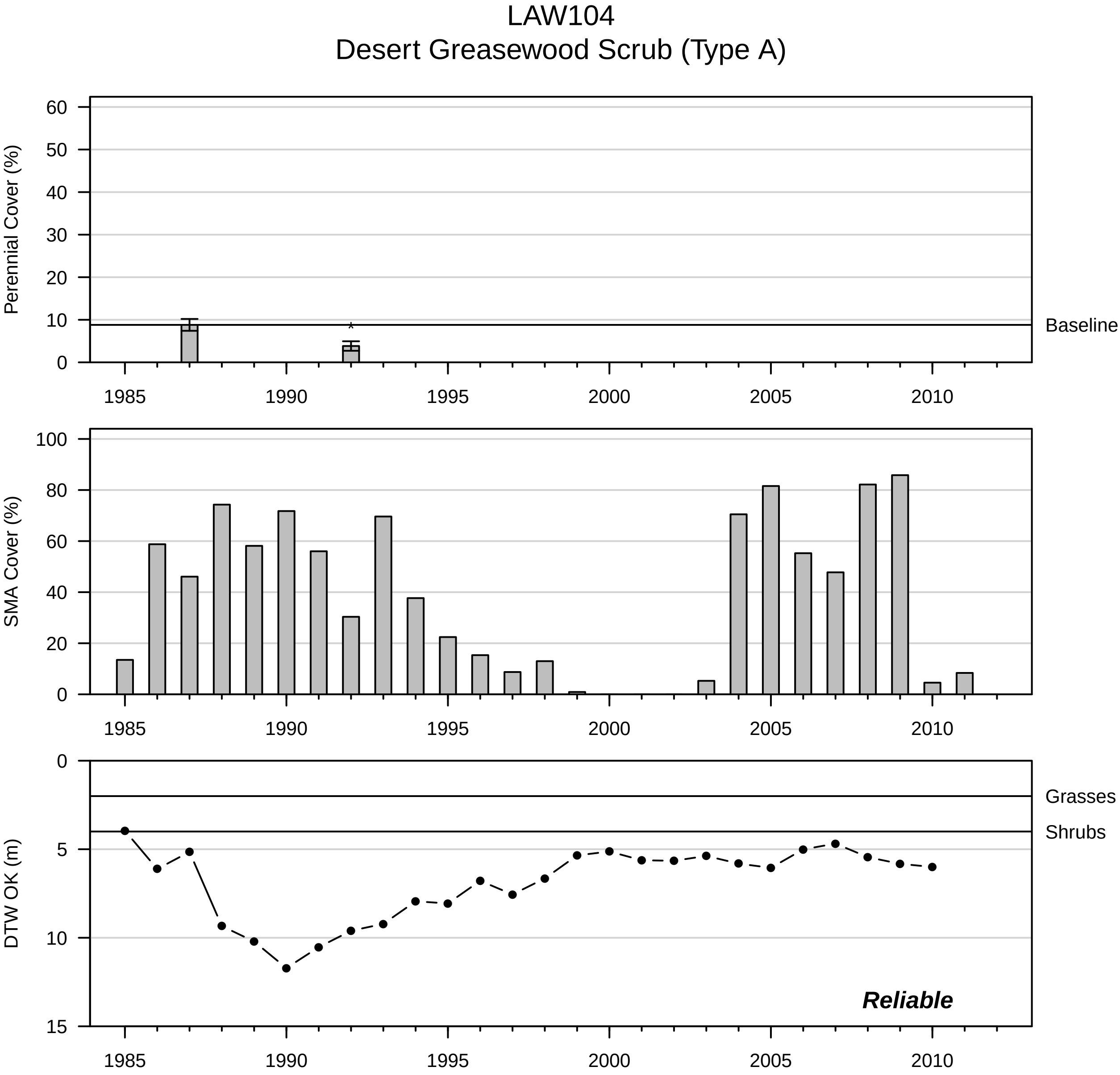
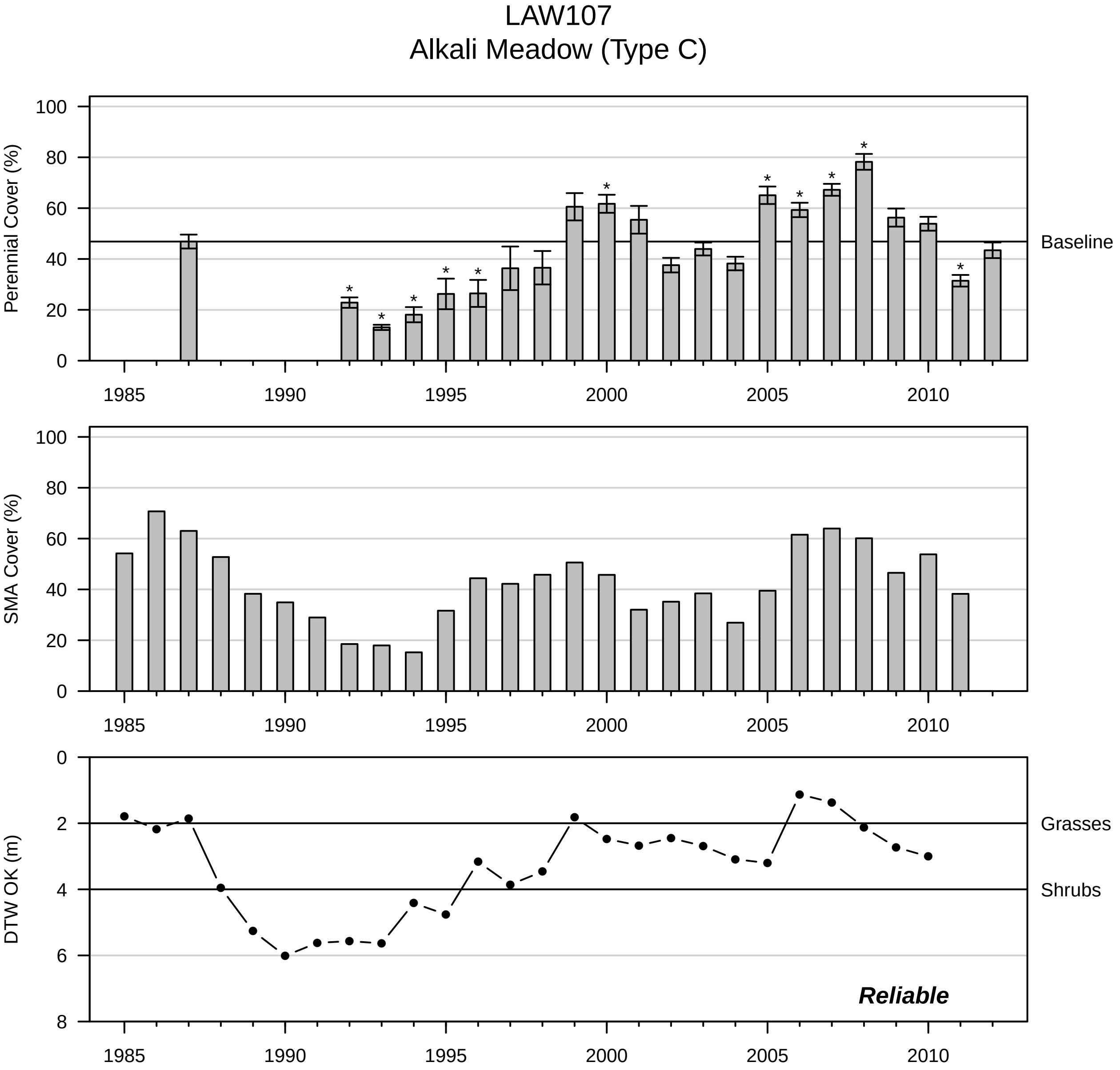


Figure 98: 1992 Wellfield



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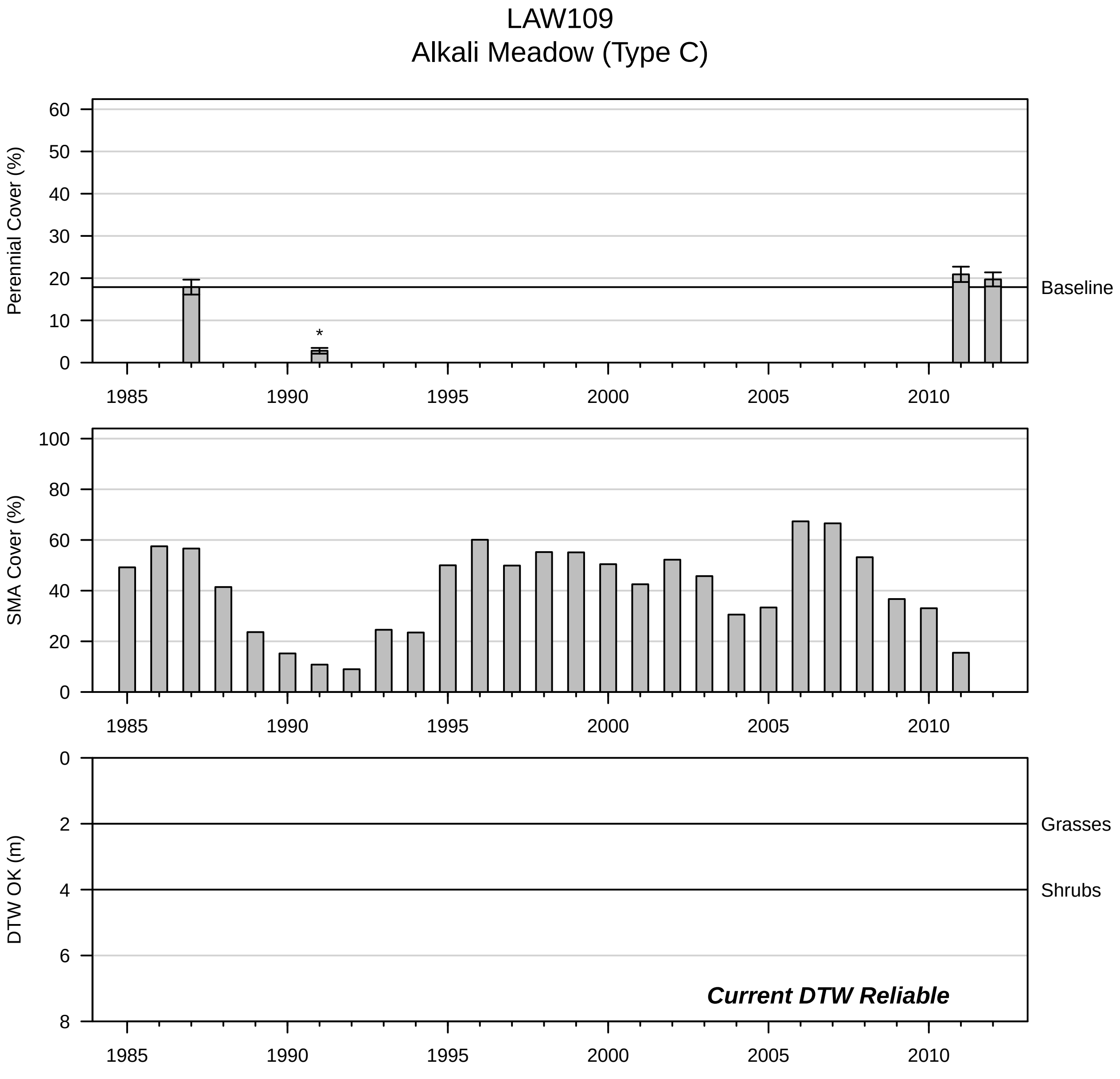

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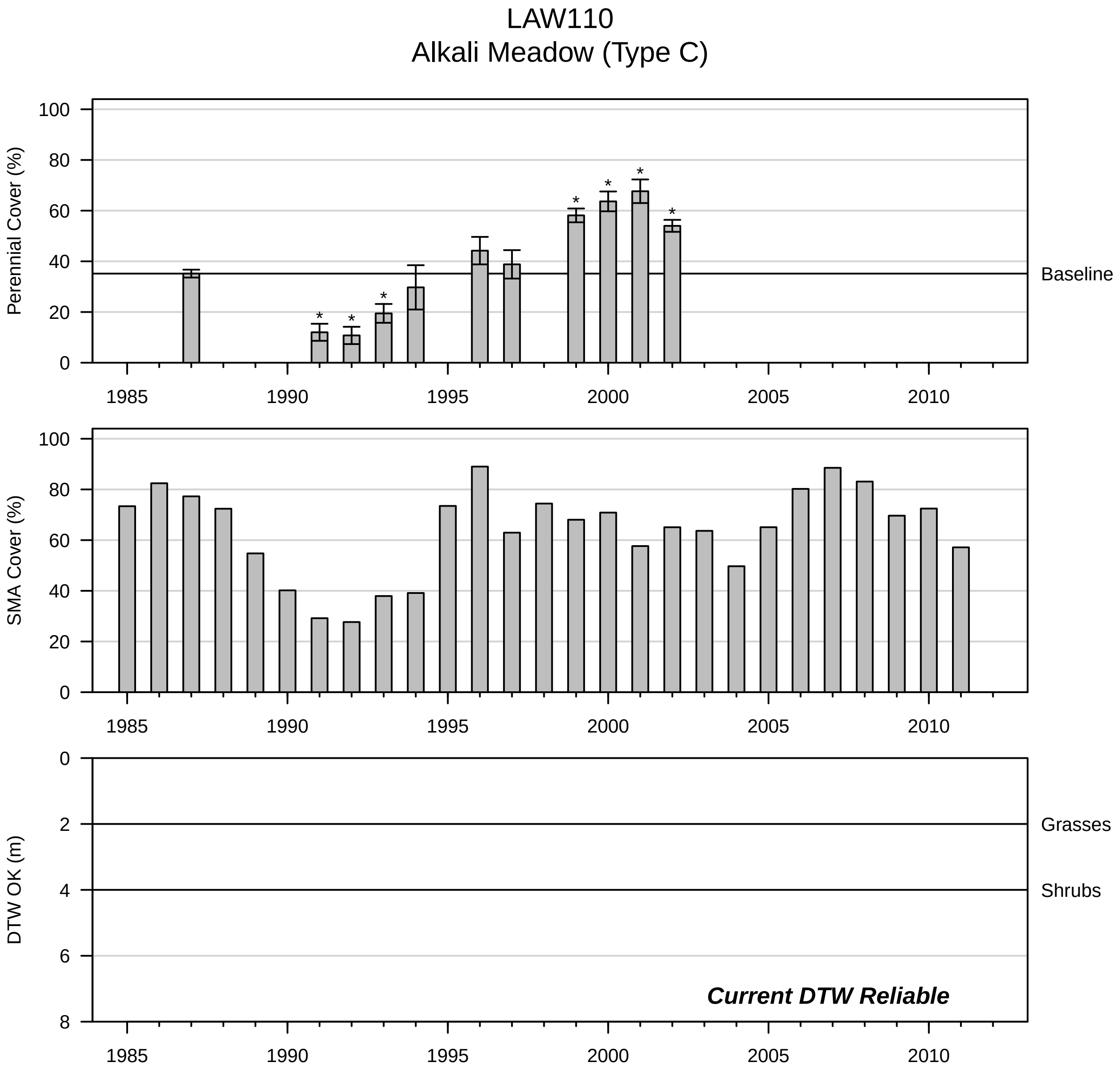


Figure 101: 2002 Wellfield

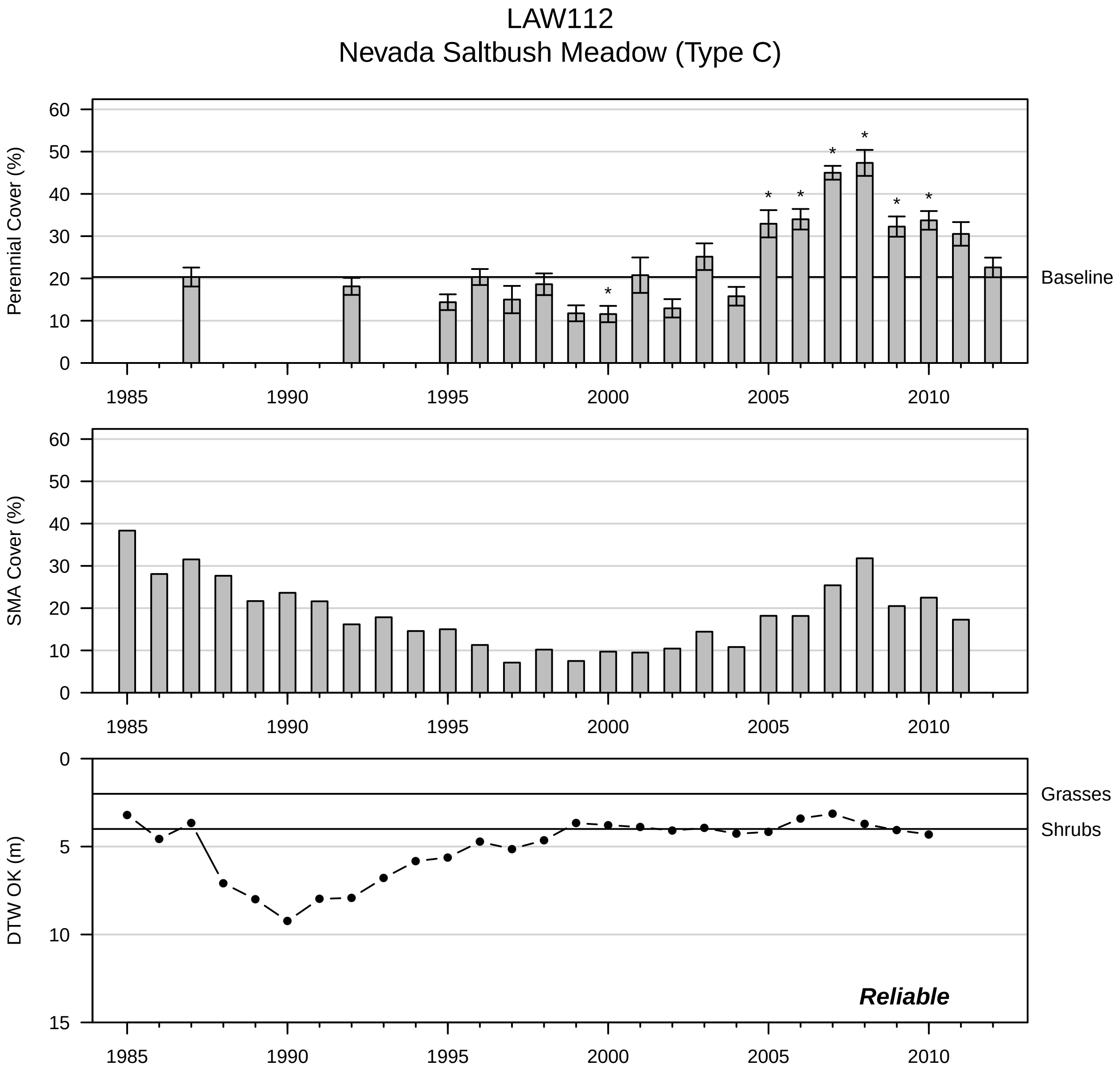
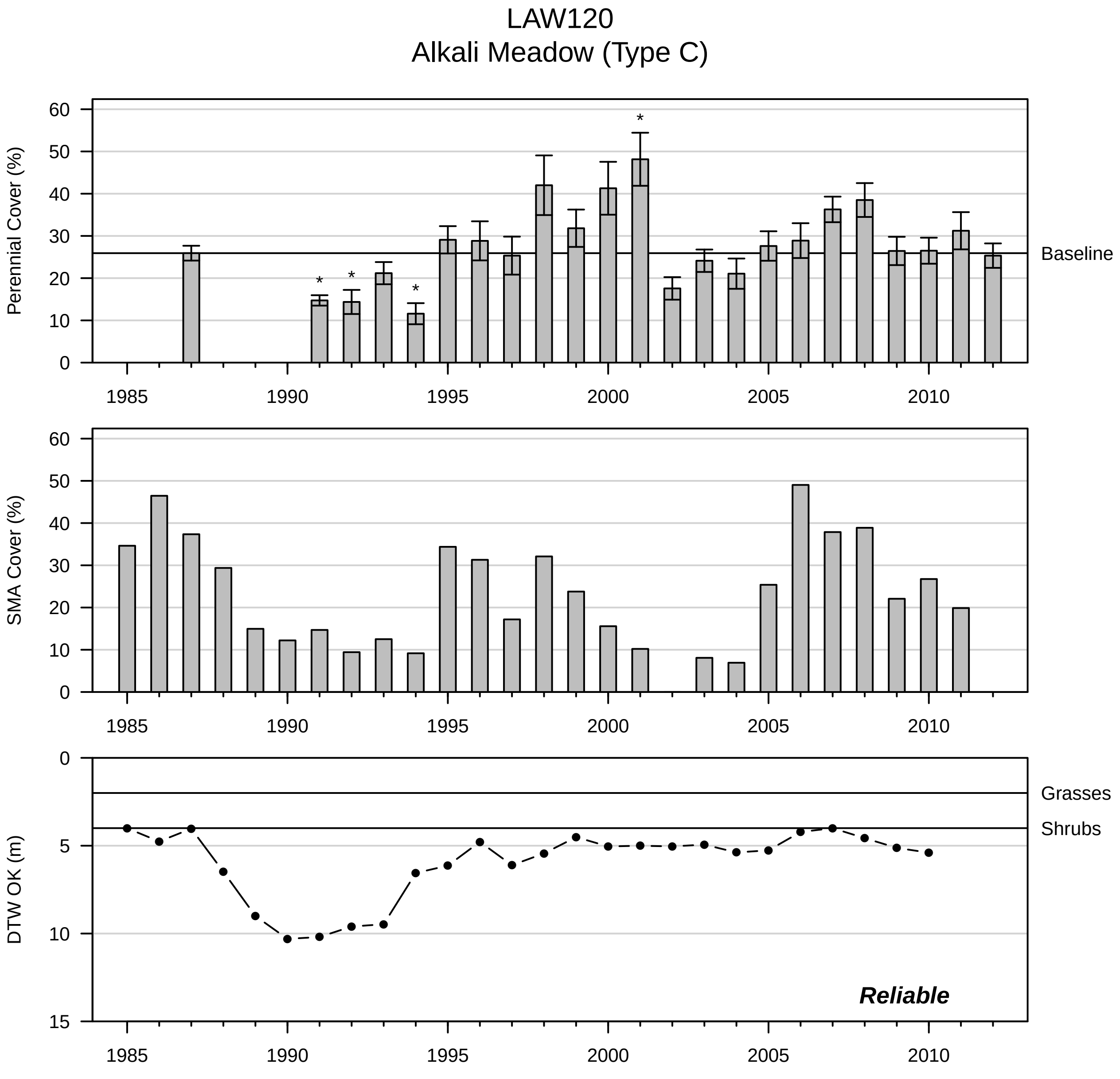


Figure 102: 2012 Wellfield



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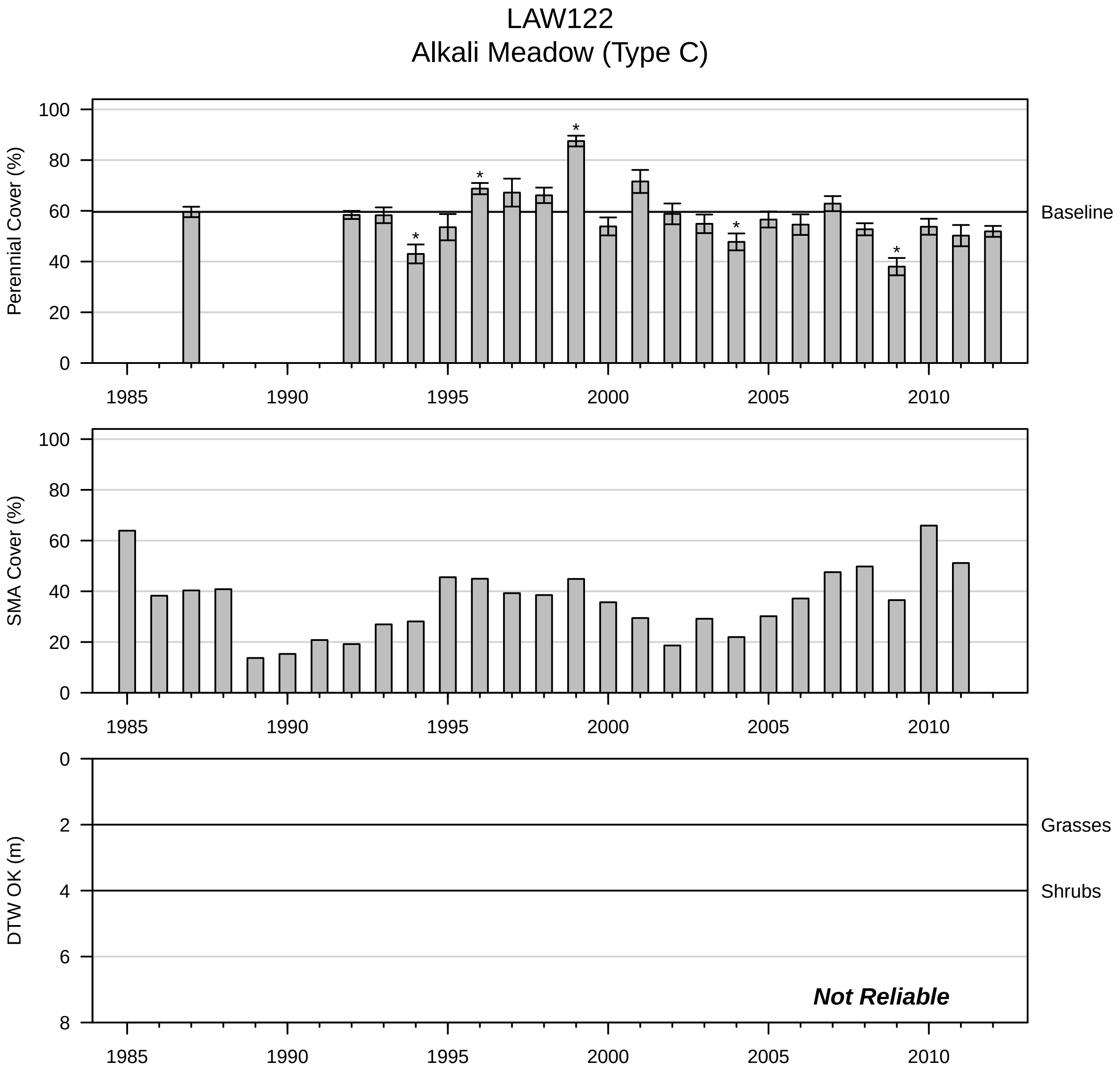

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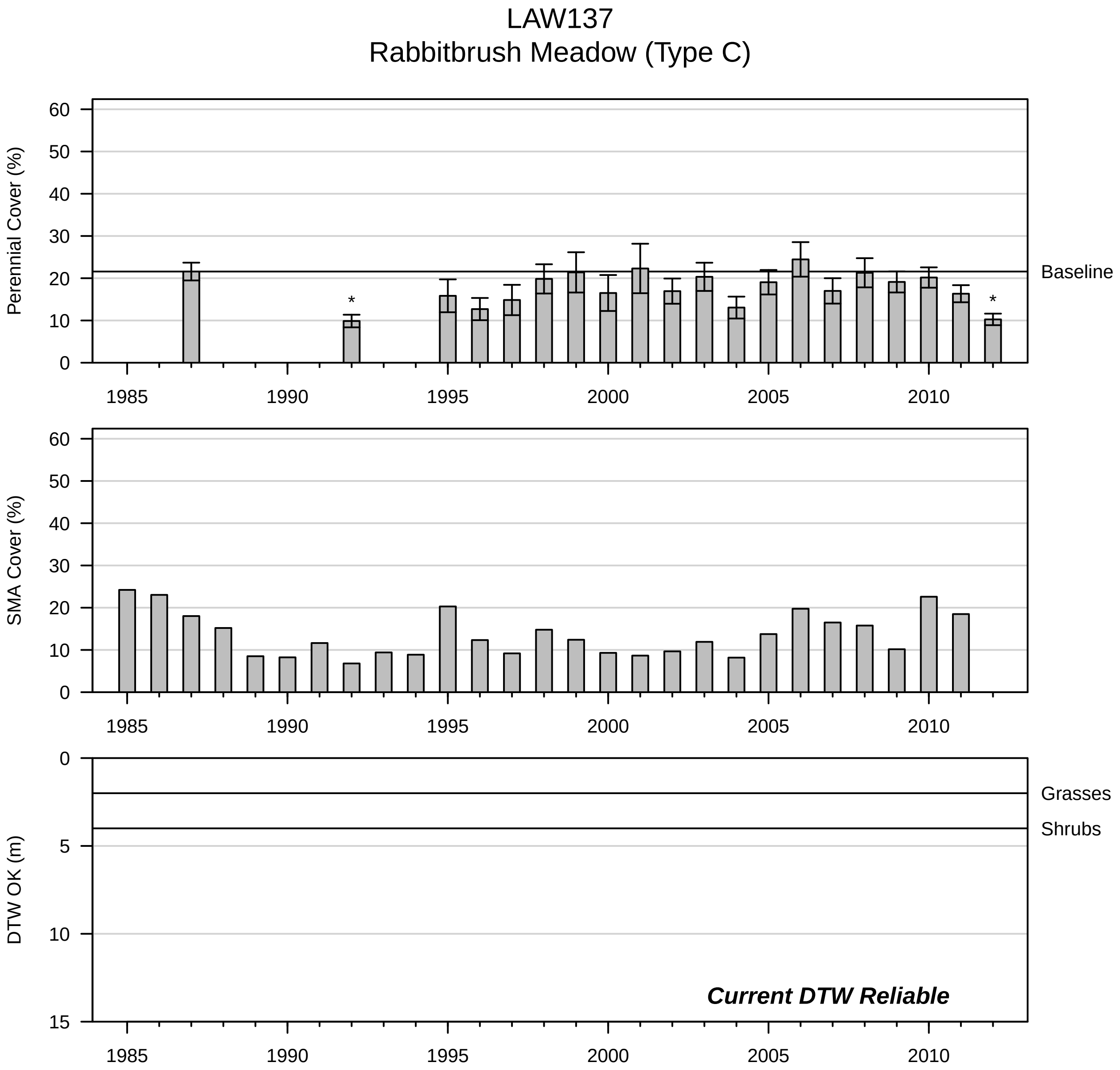

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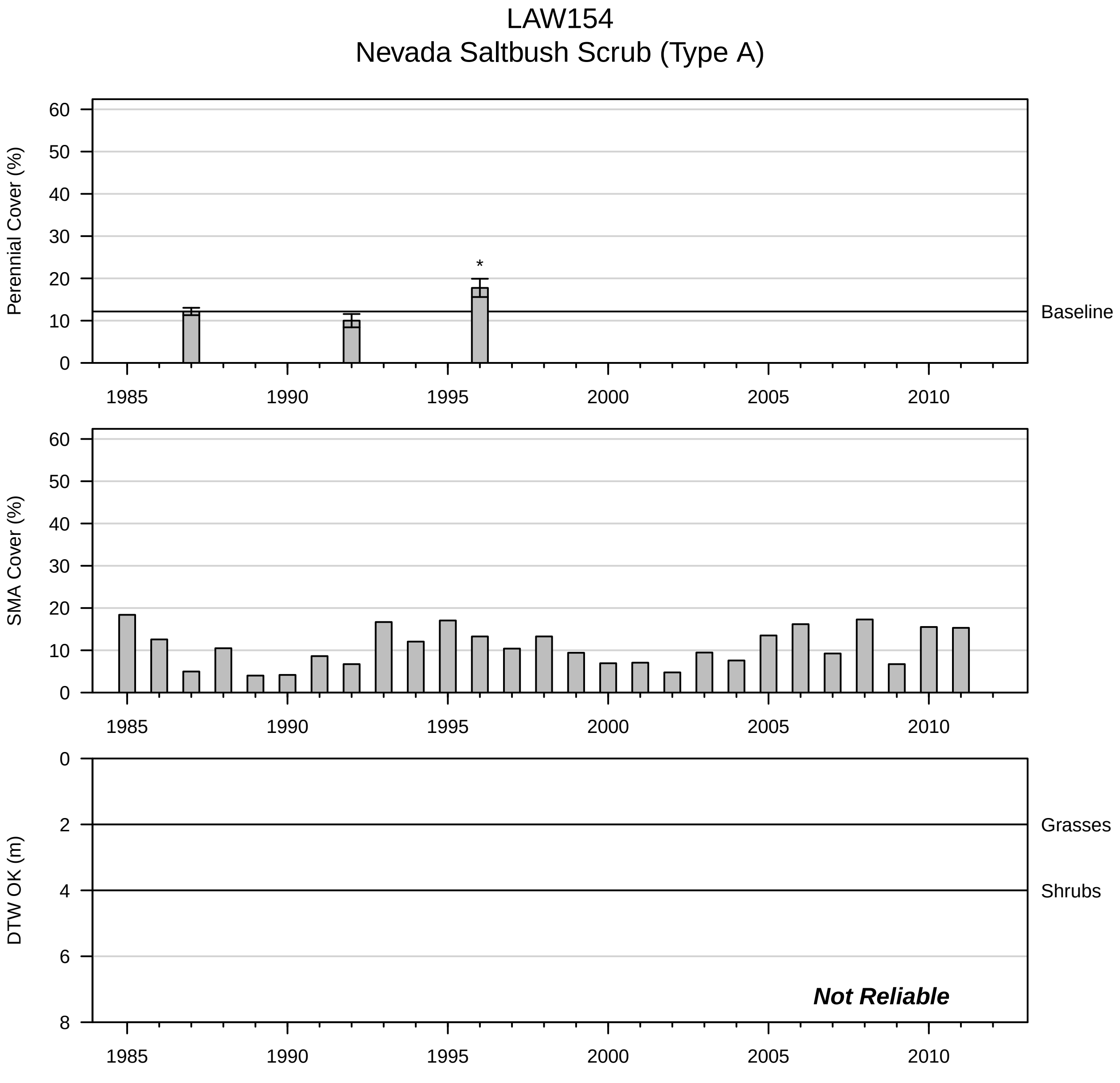


Figure 106: 1996 Control

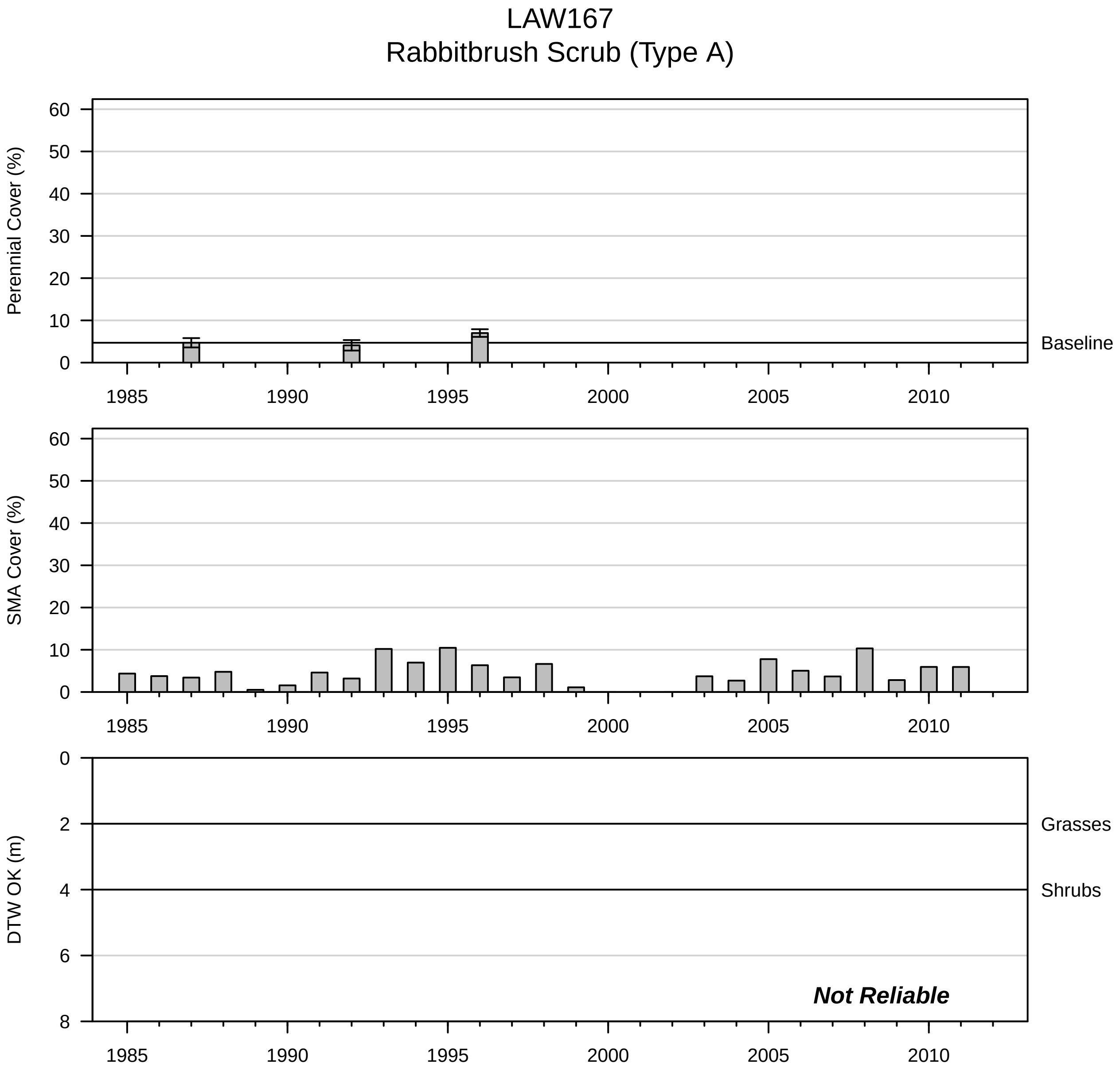
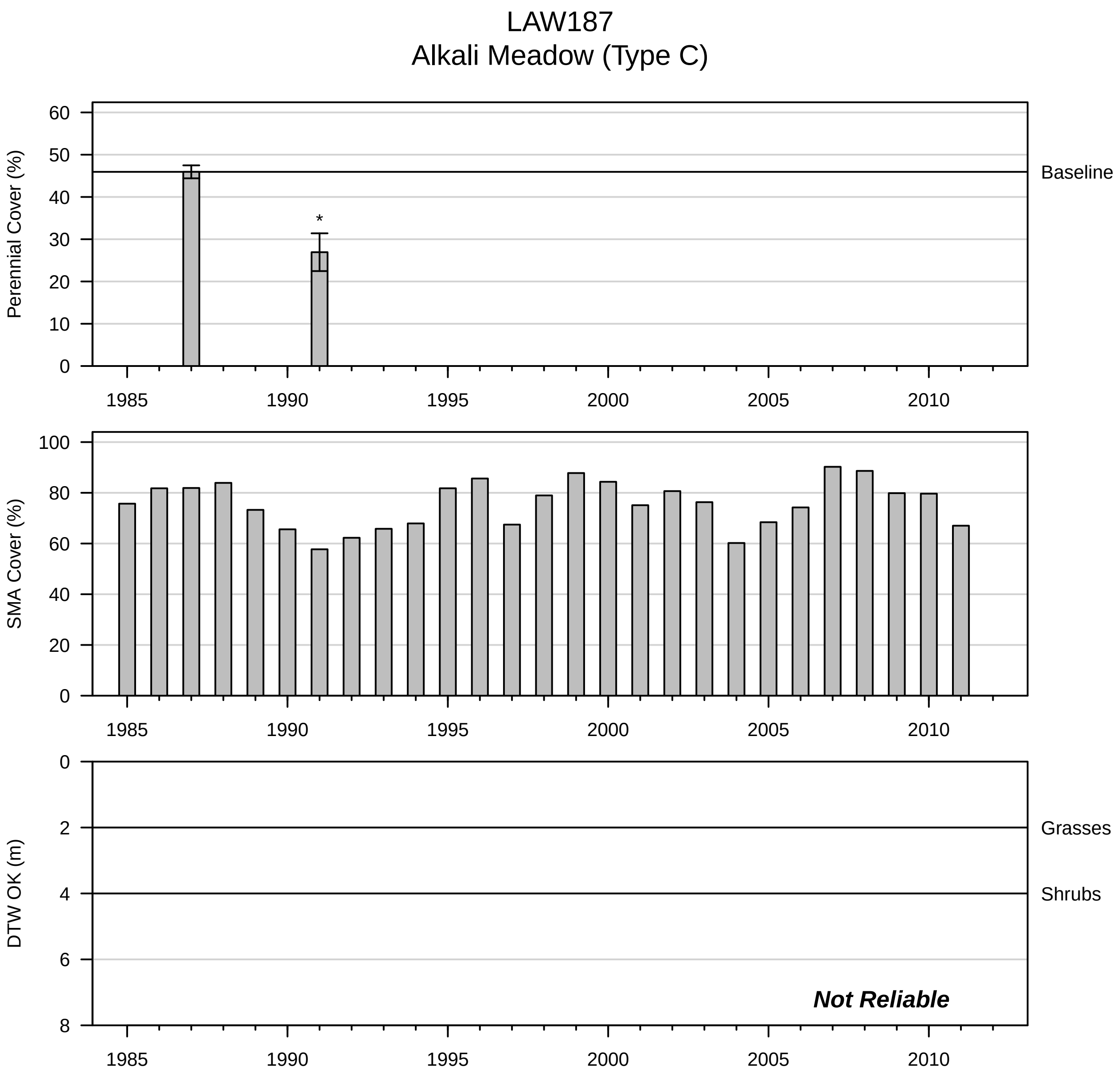


Figure 107: 1996 Control



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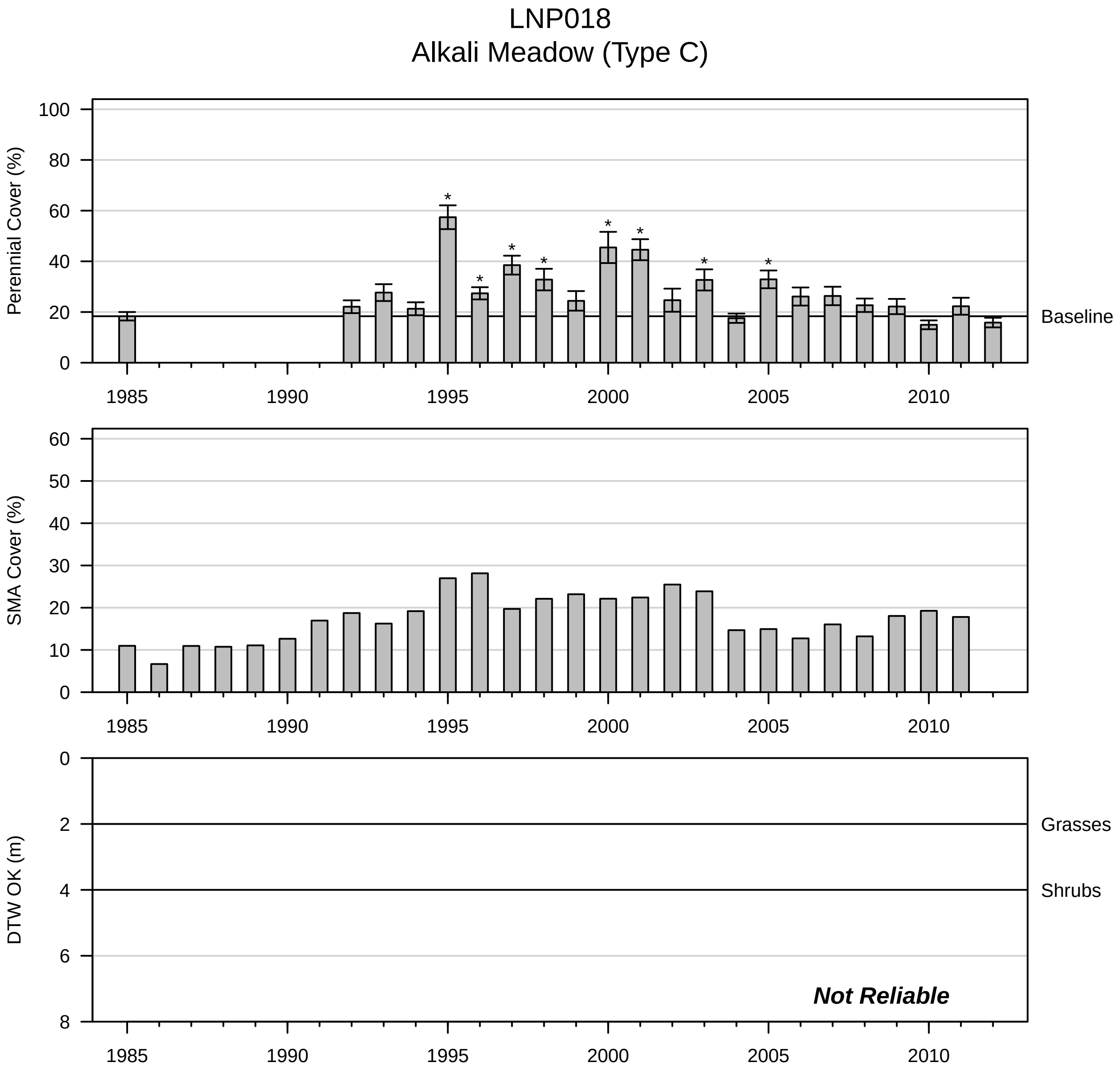

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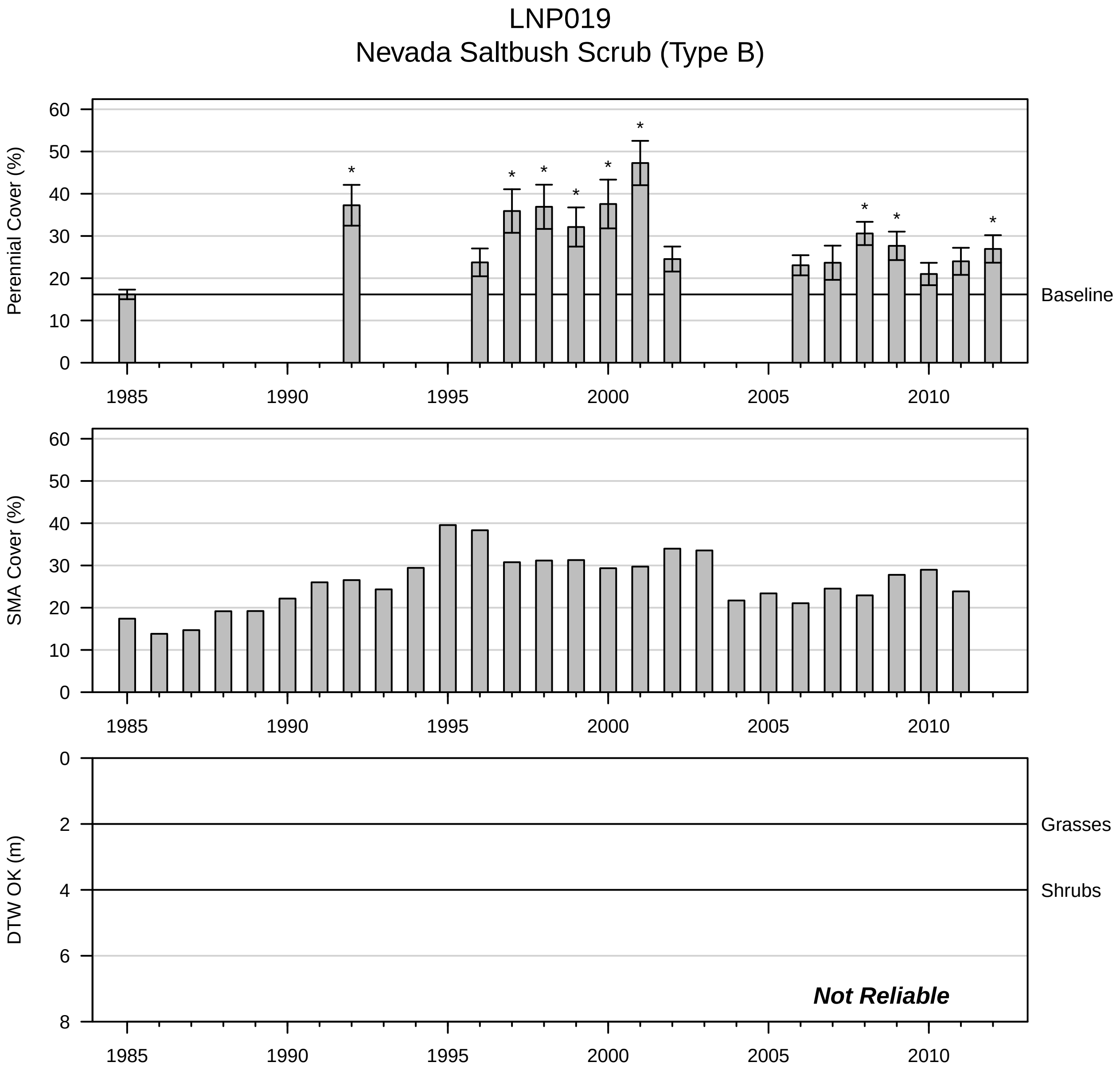

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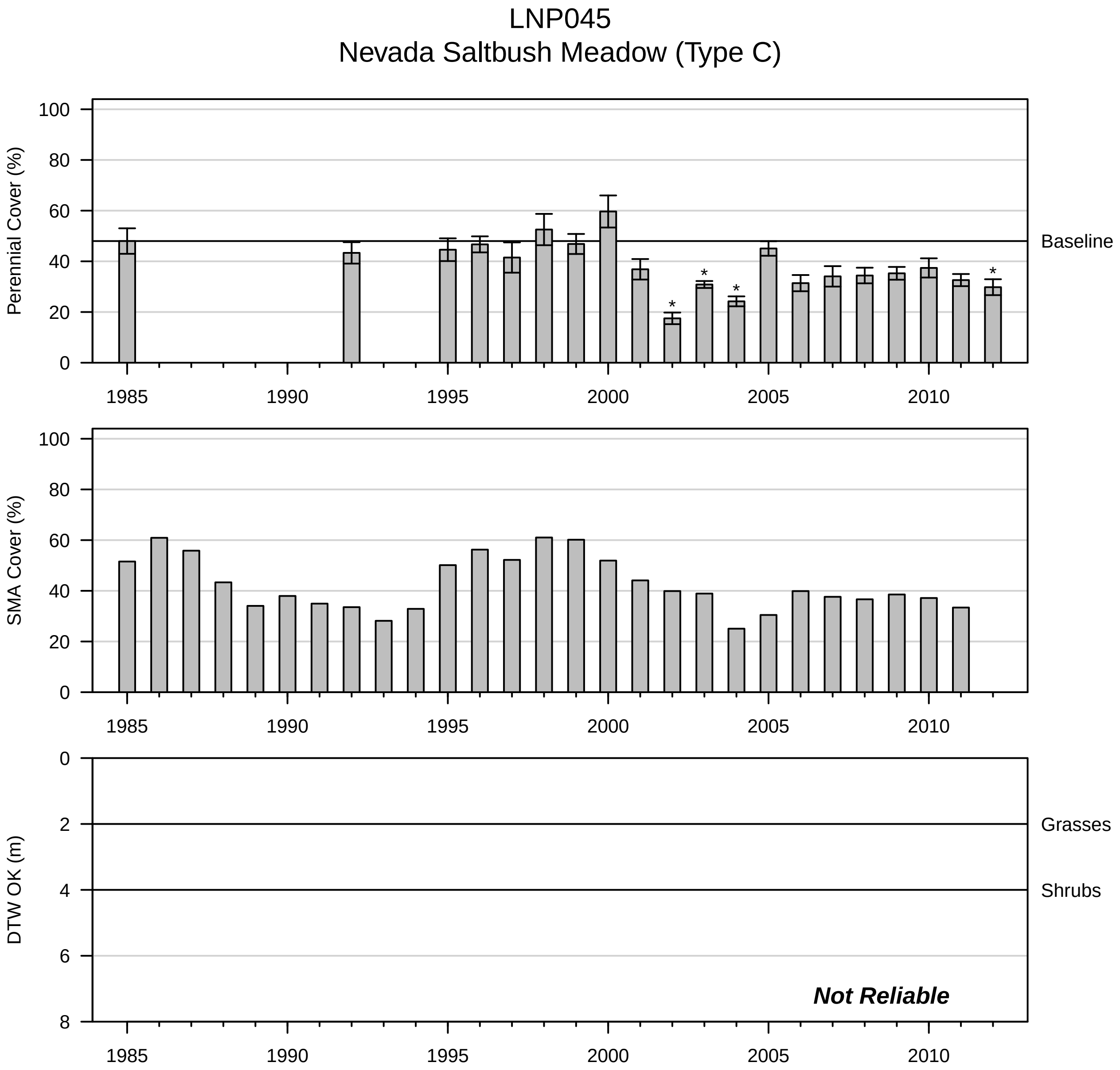


Figure 111: 2012 Wellfield

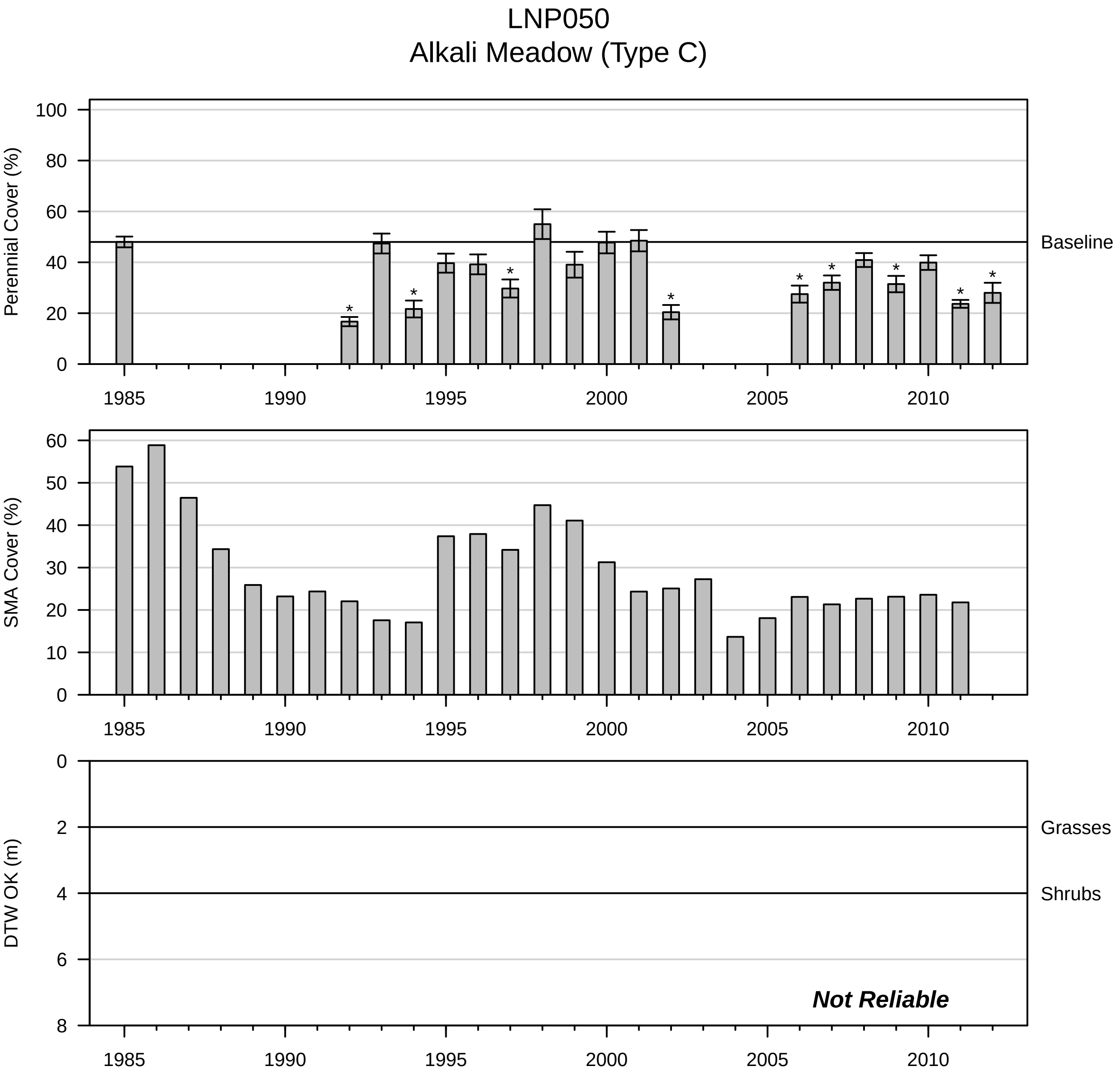


Figure 112: 2012 Control

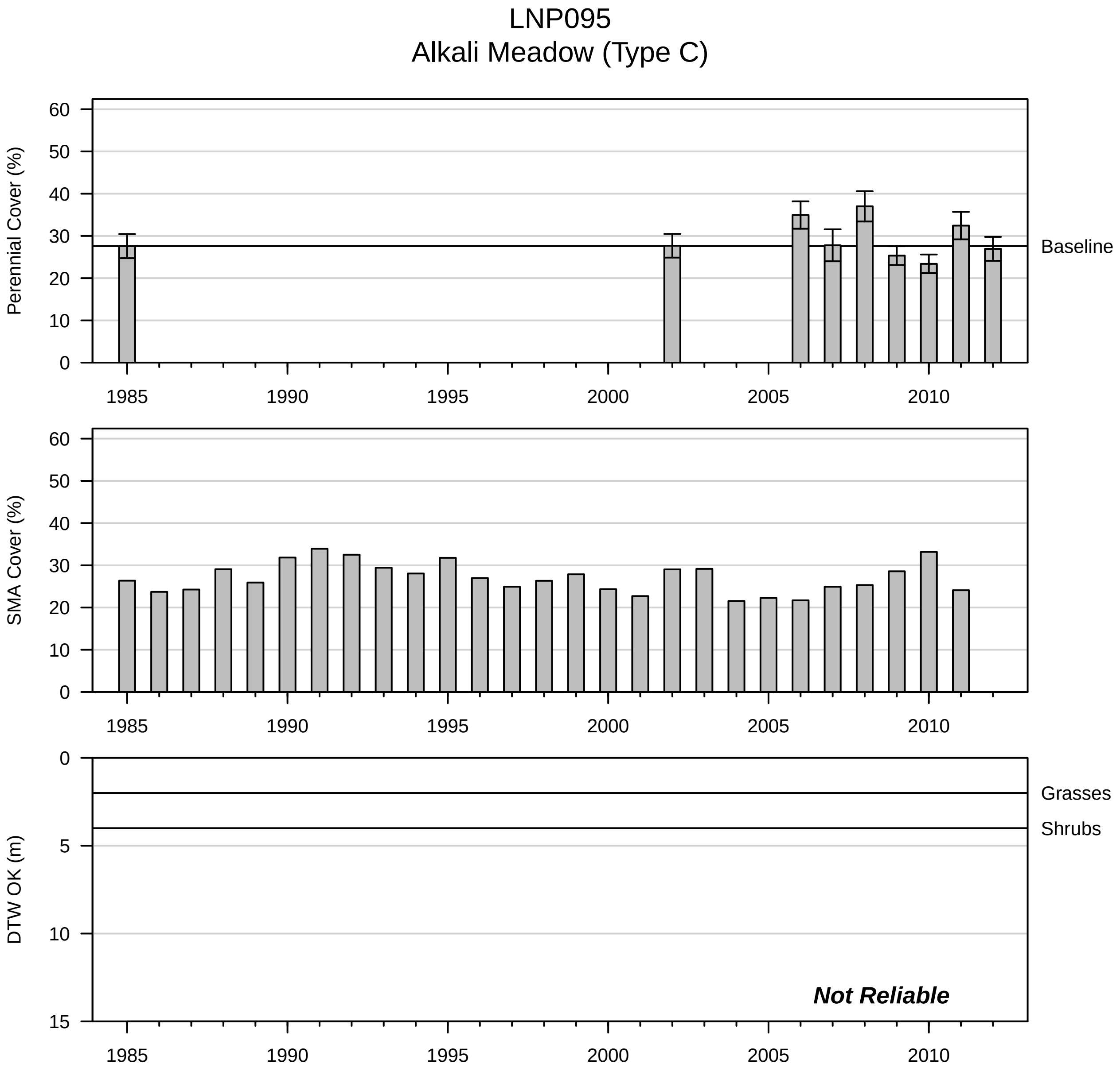


Figure 113: 2012 Control

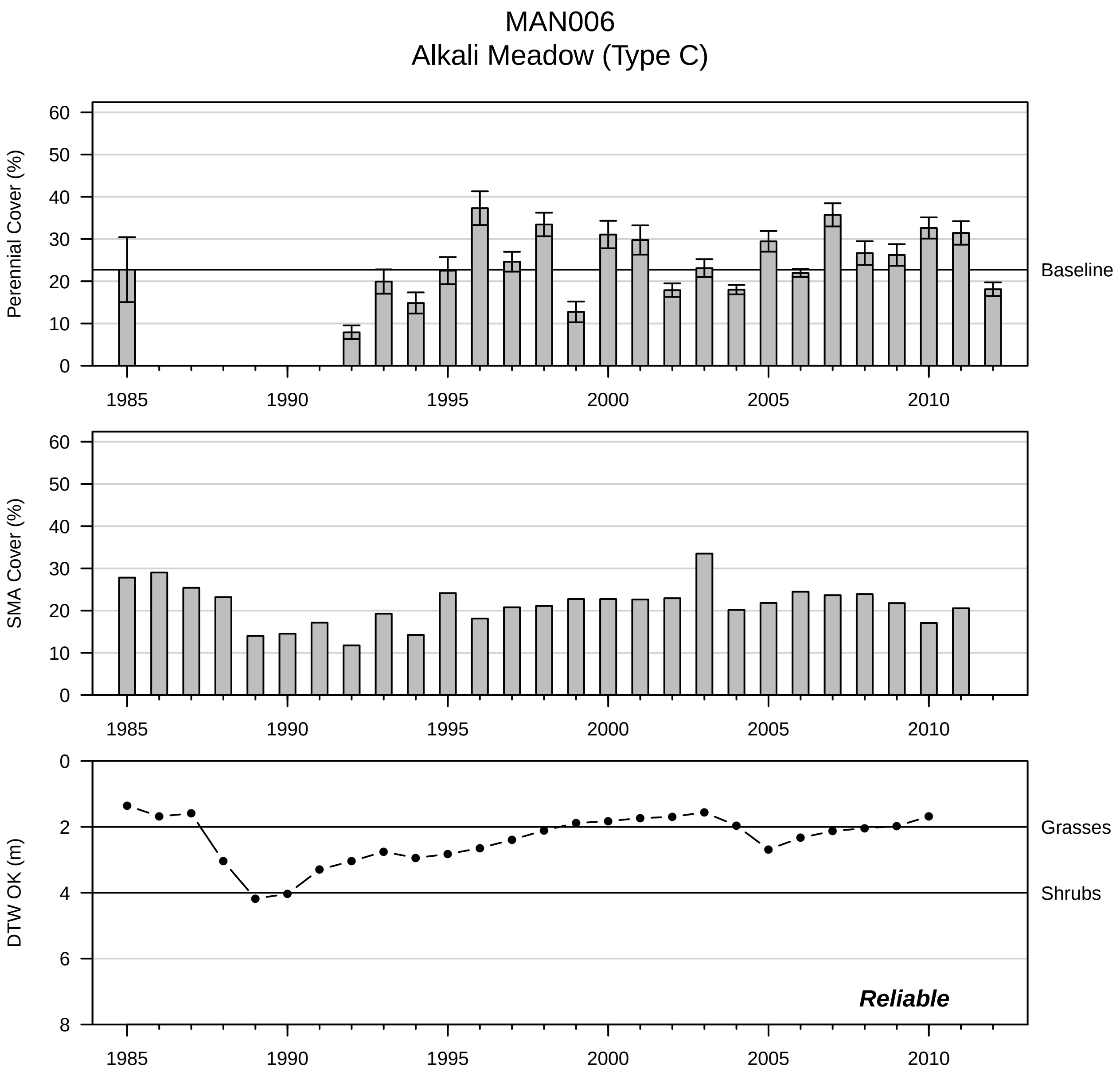


Figure 114: 2012 Wellfield

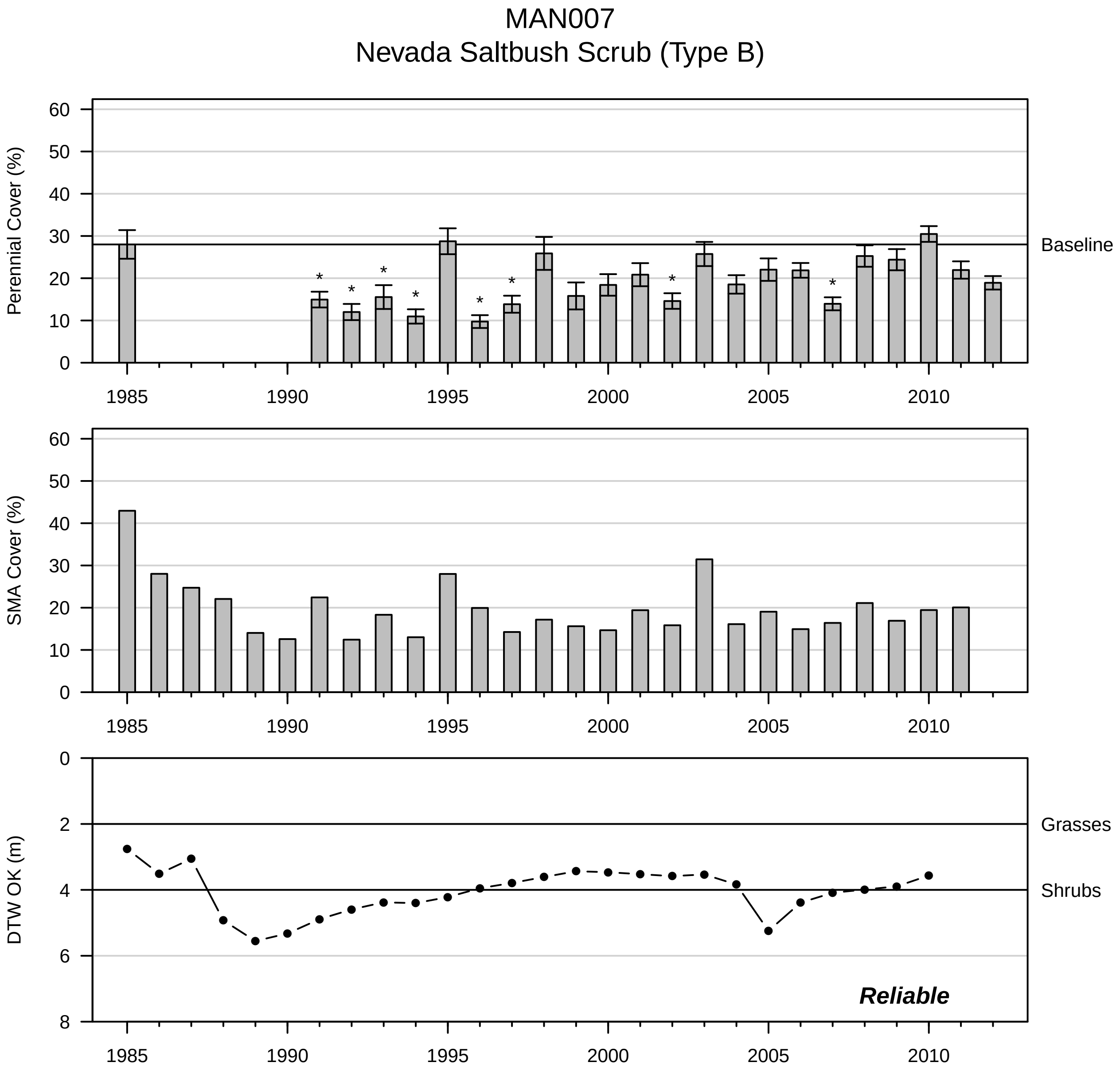


Figure 115: 2012 Wellfield

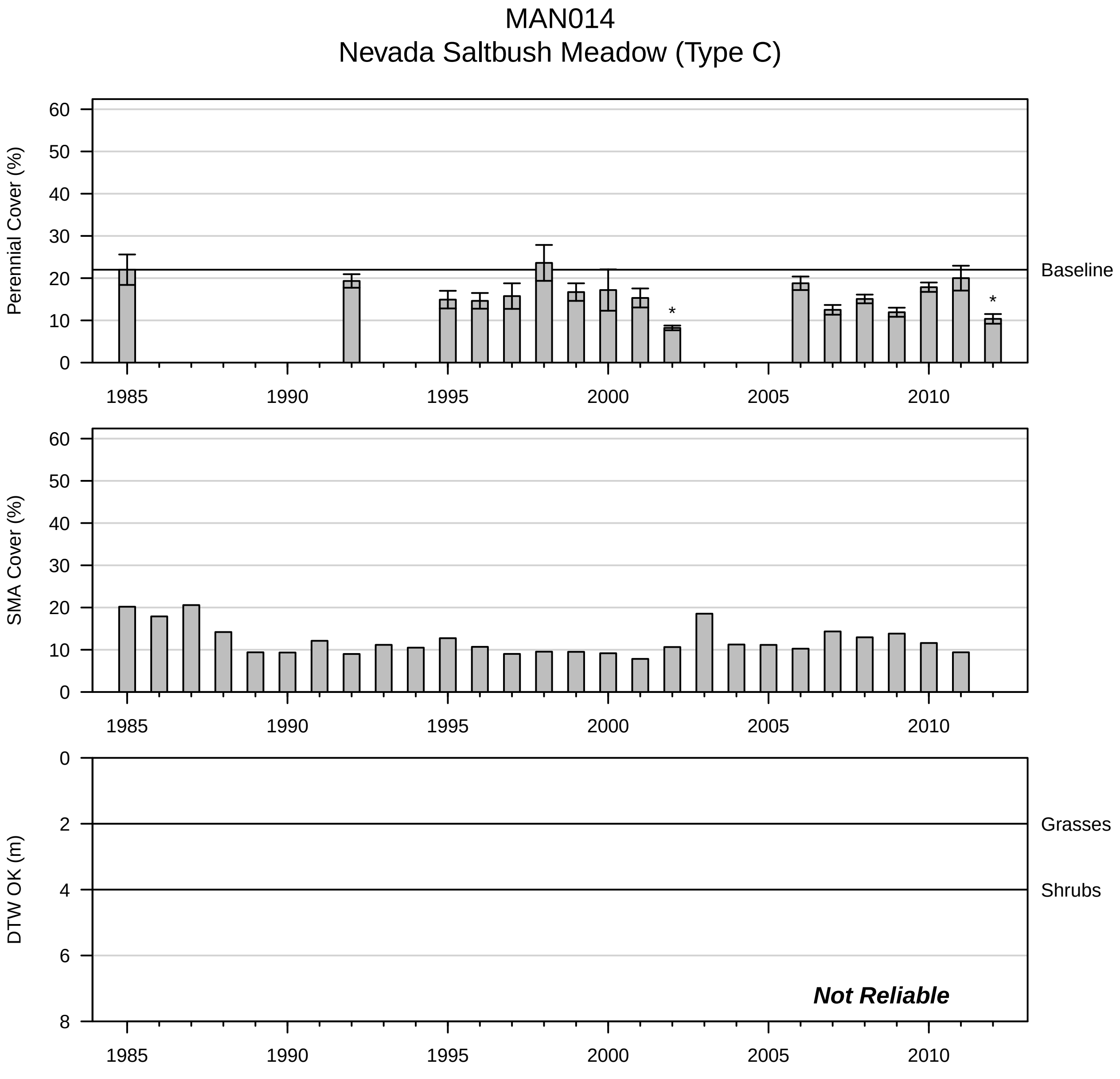


Figure 116: 2012 Control

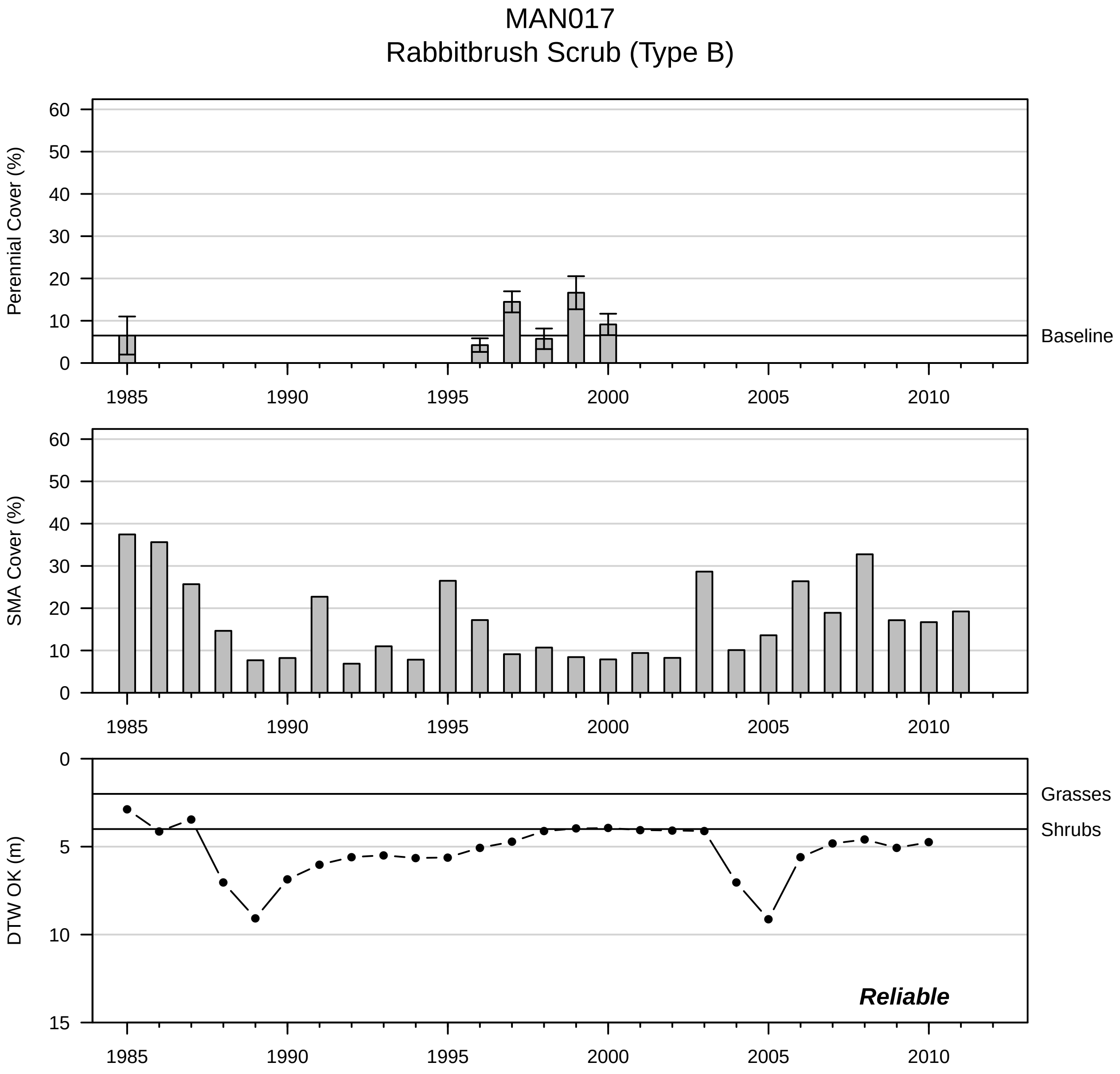


Figure 117: 2000 Wellfield

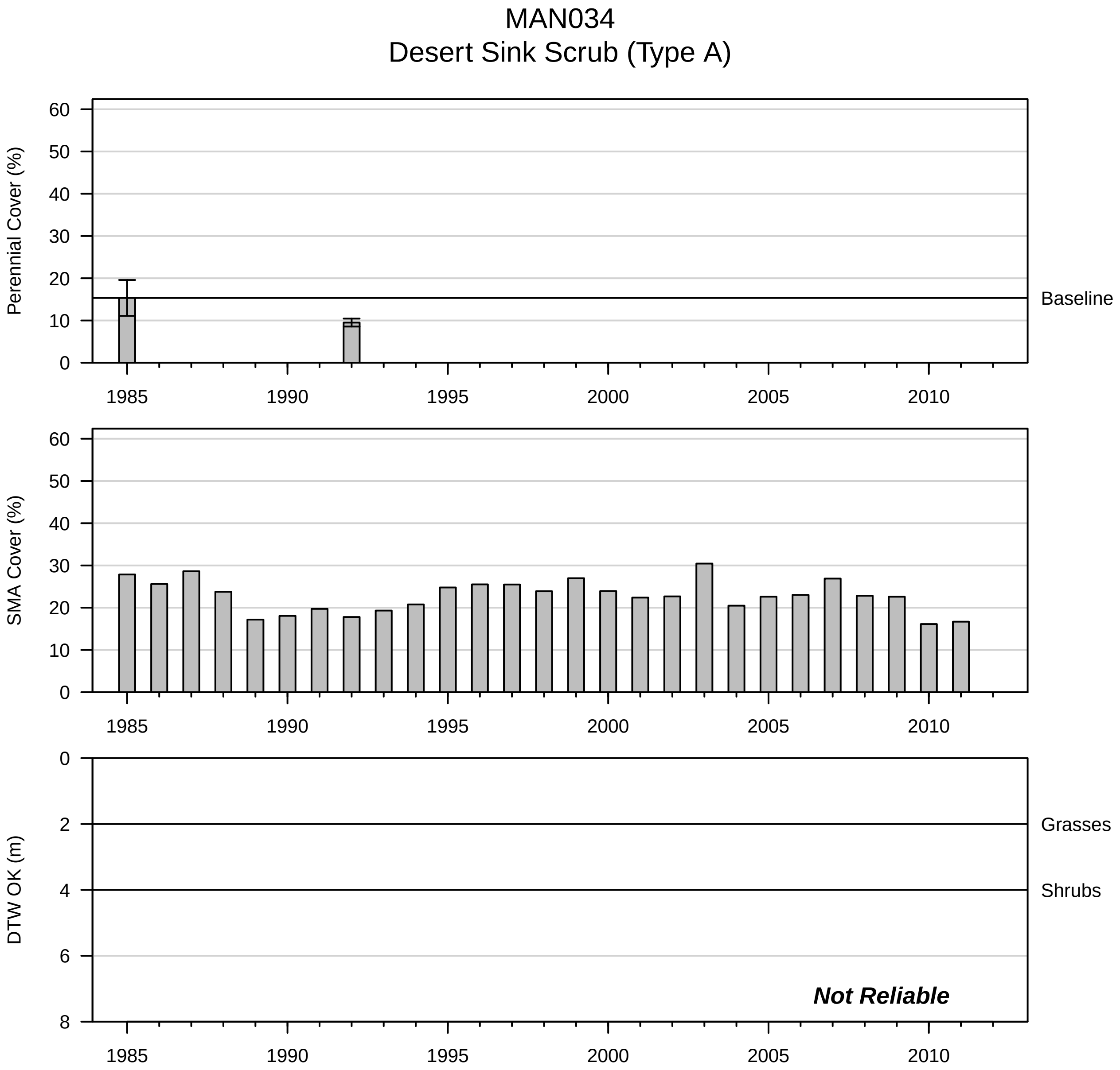


Figure 118: 1992 Wellfield

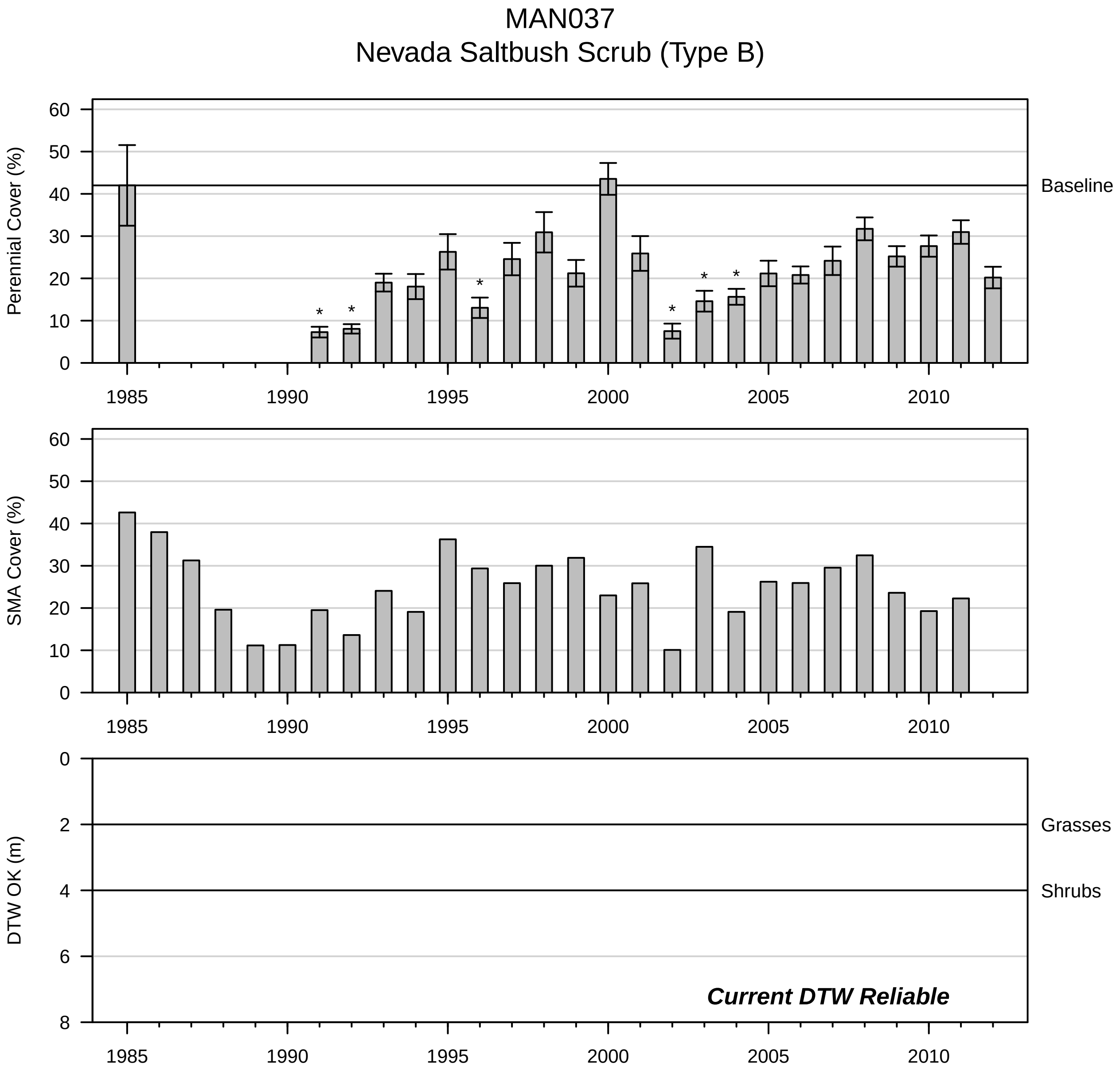


Figure 119: 2012 Wellfield

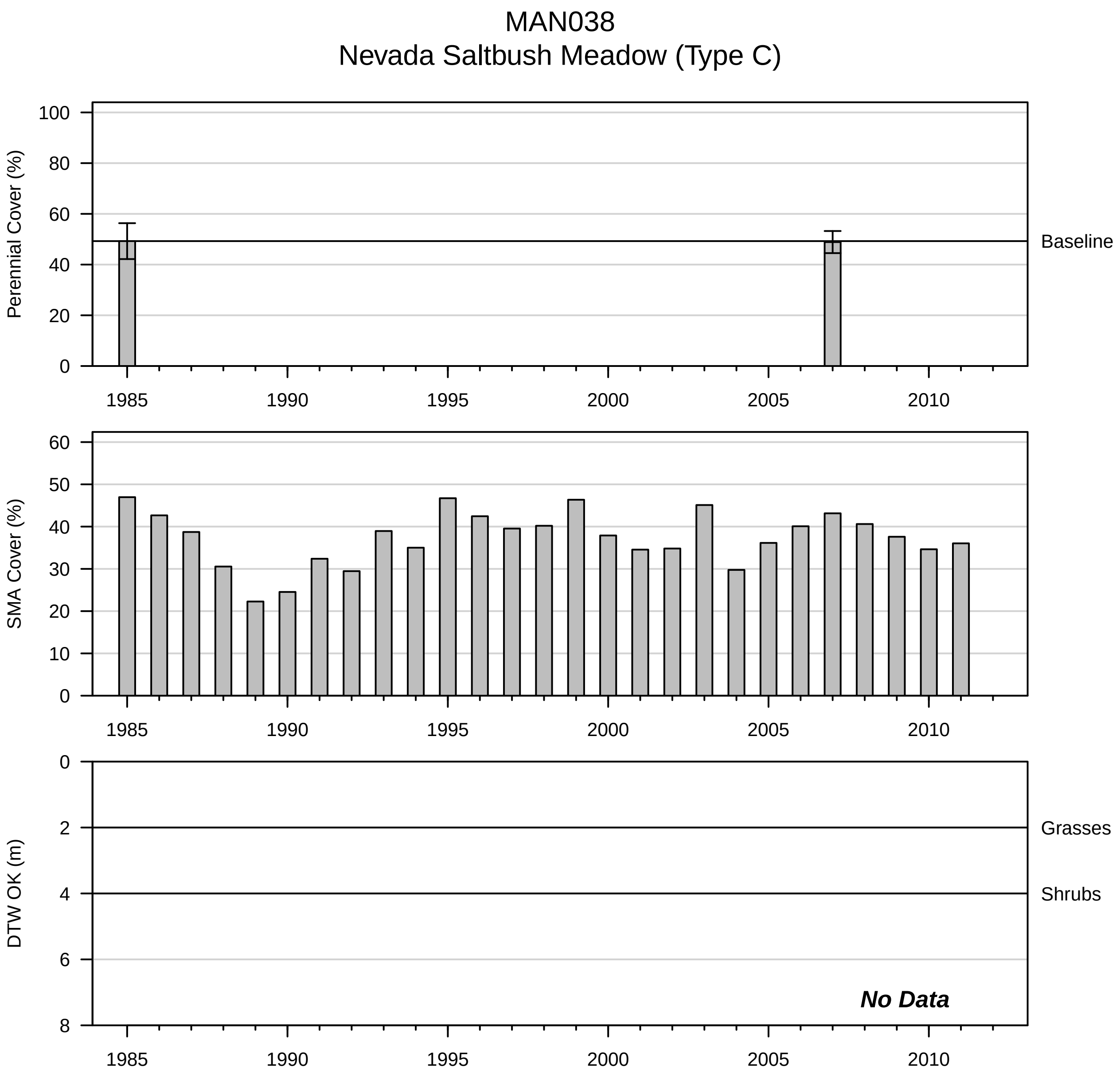


Figure 120: 2007 Wellfield

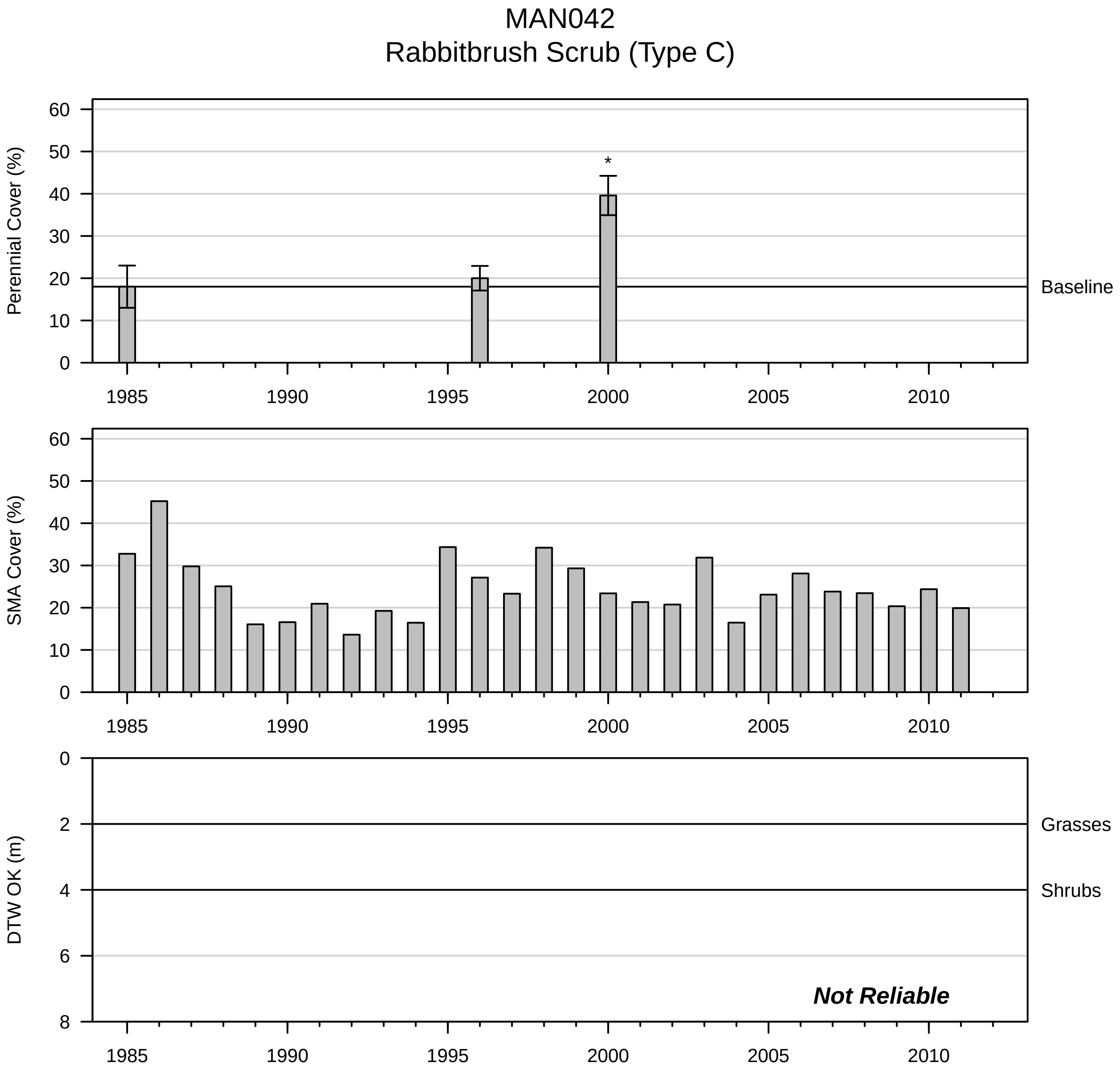


Figure 121: 2000 Wellfield

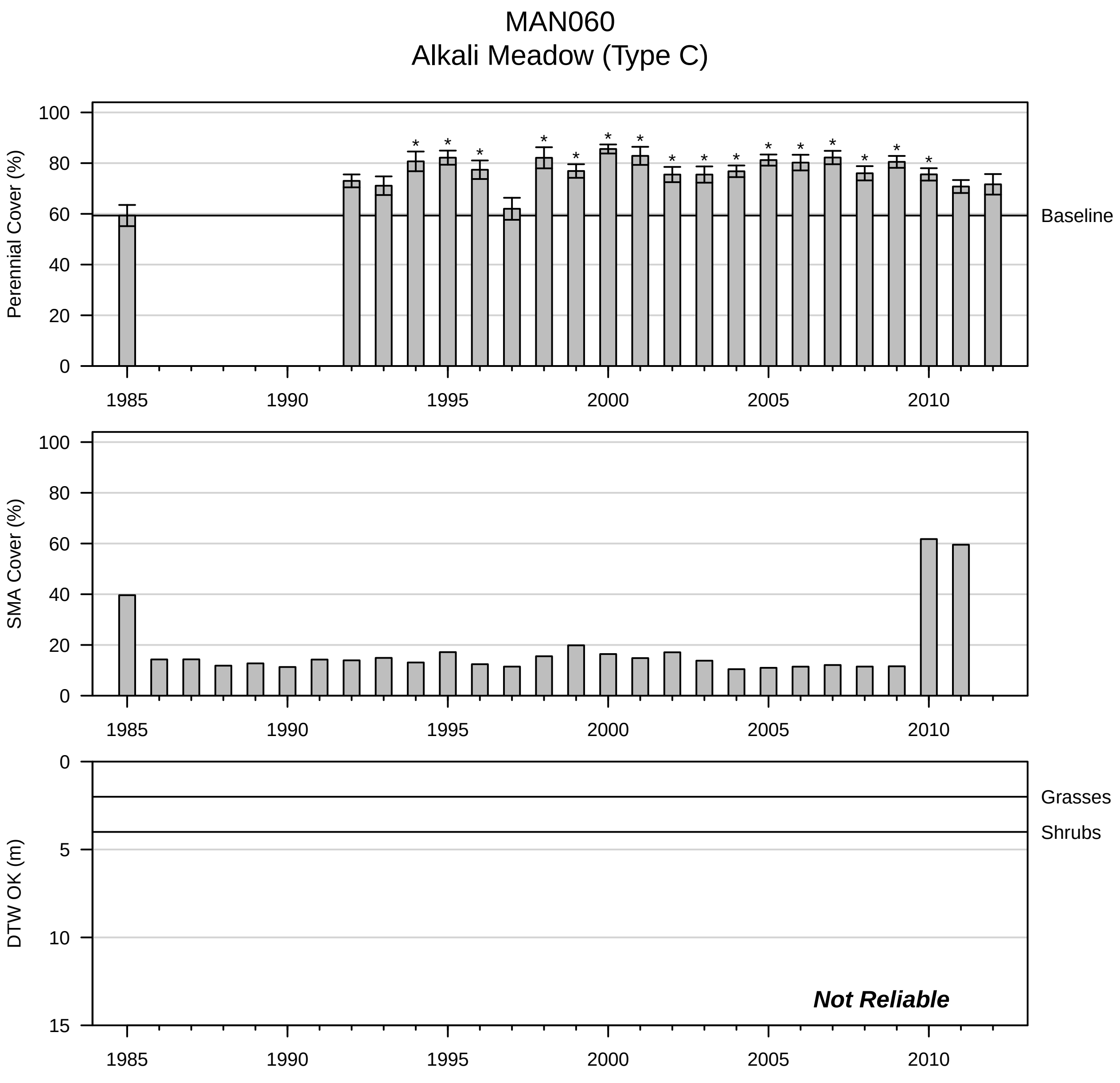


Figure 122: 2012 Control

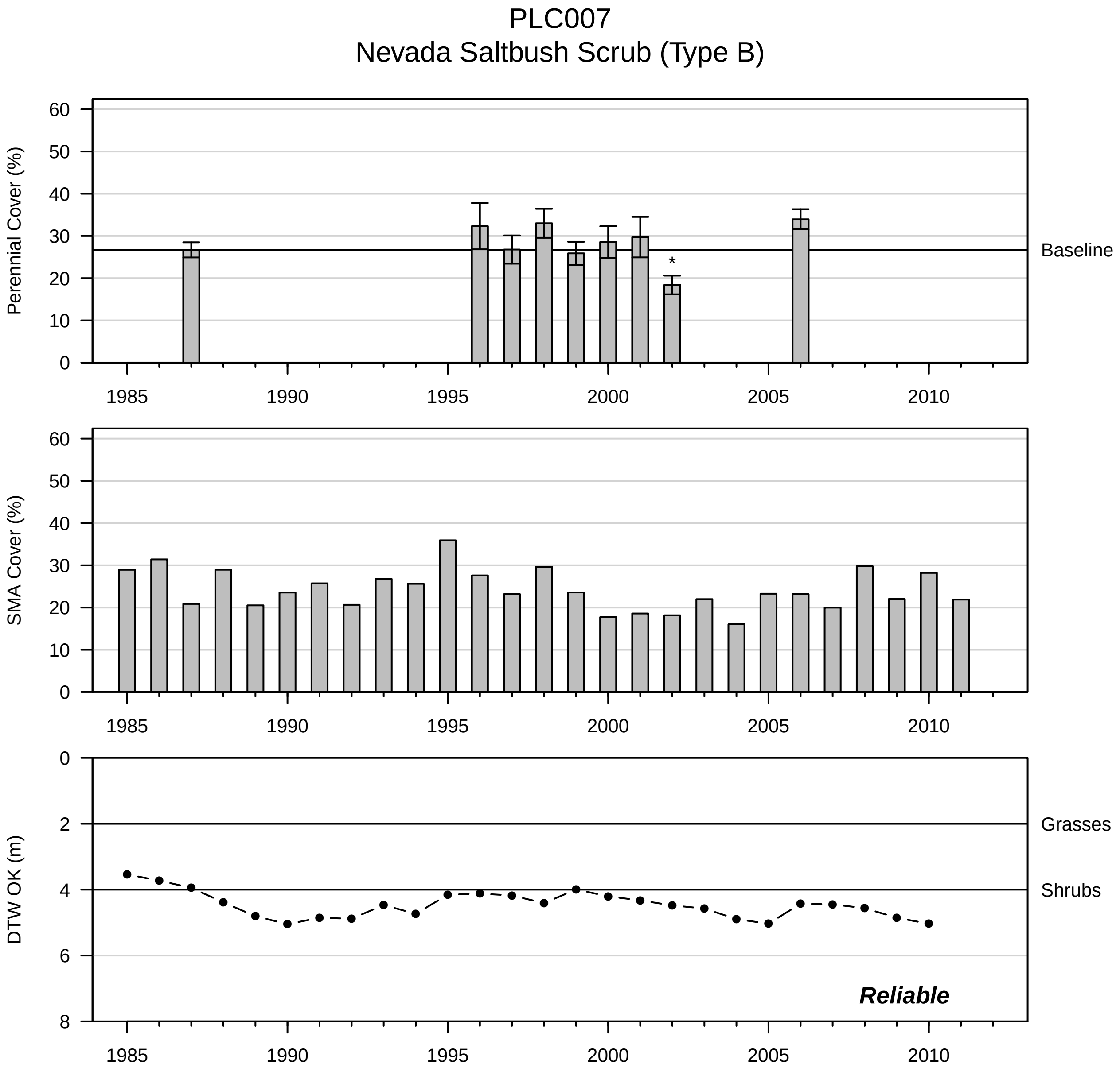


Figure 123: 2006 Wellfield

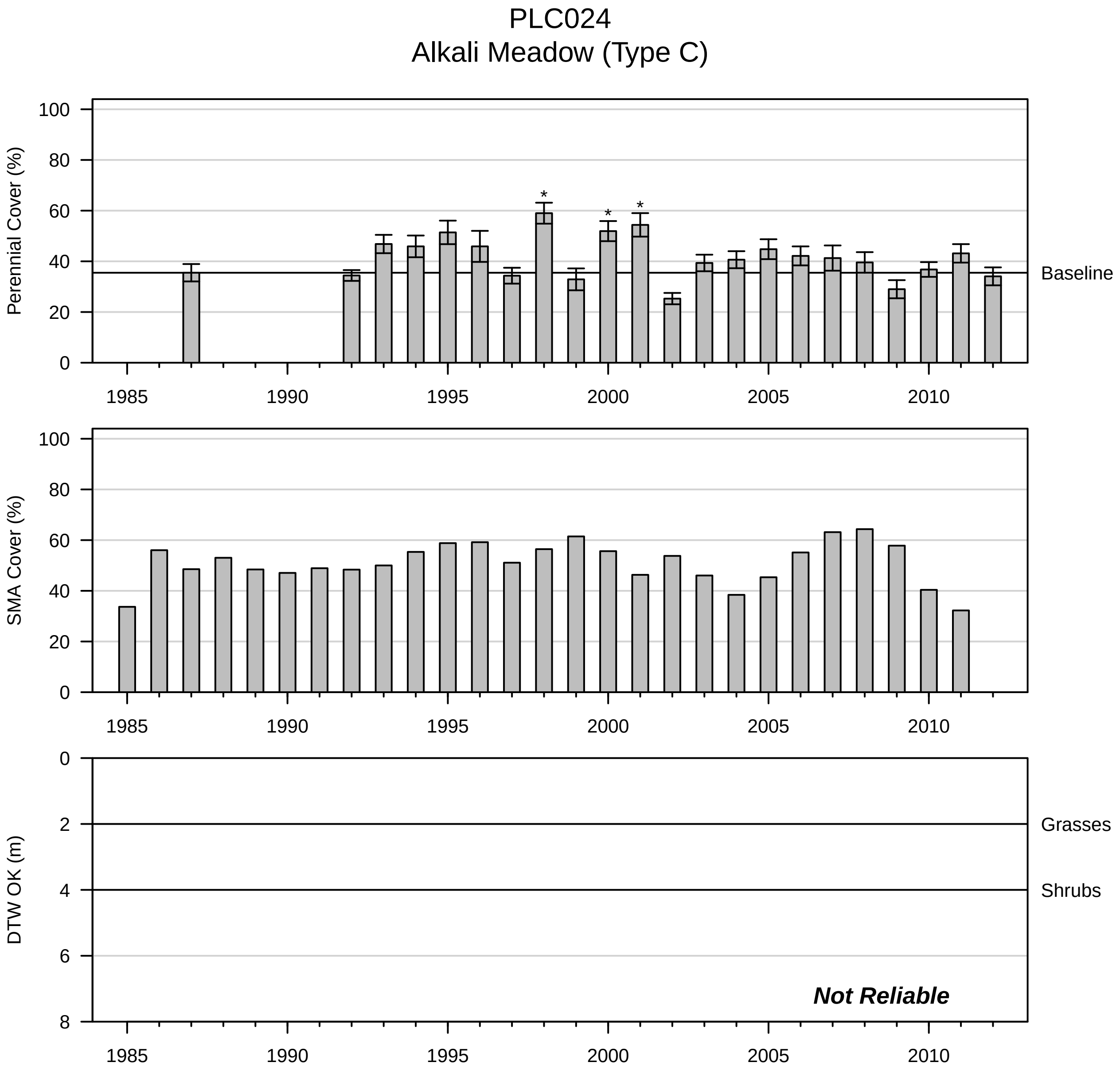


Figure 124: 2012 Control

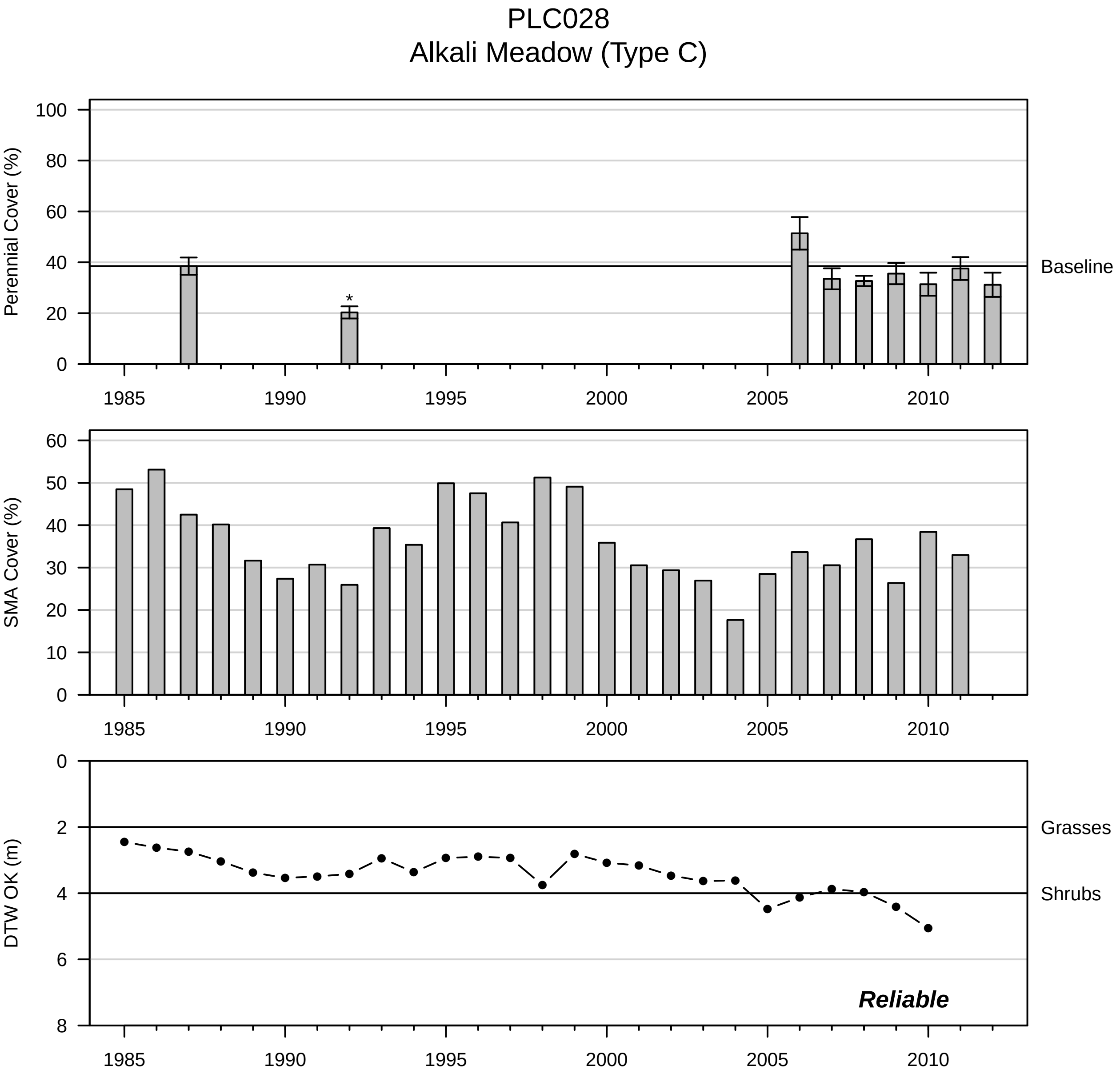


Figure 125: 2012 Control

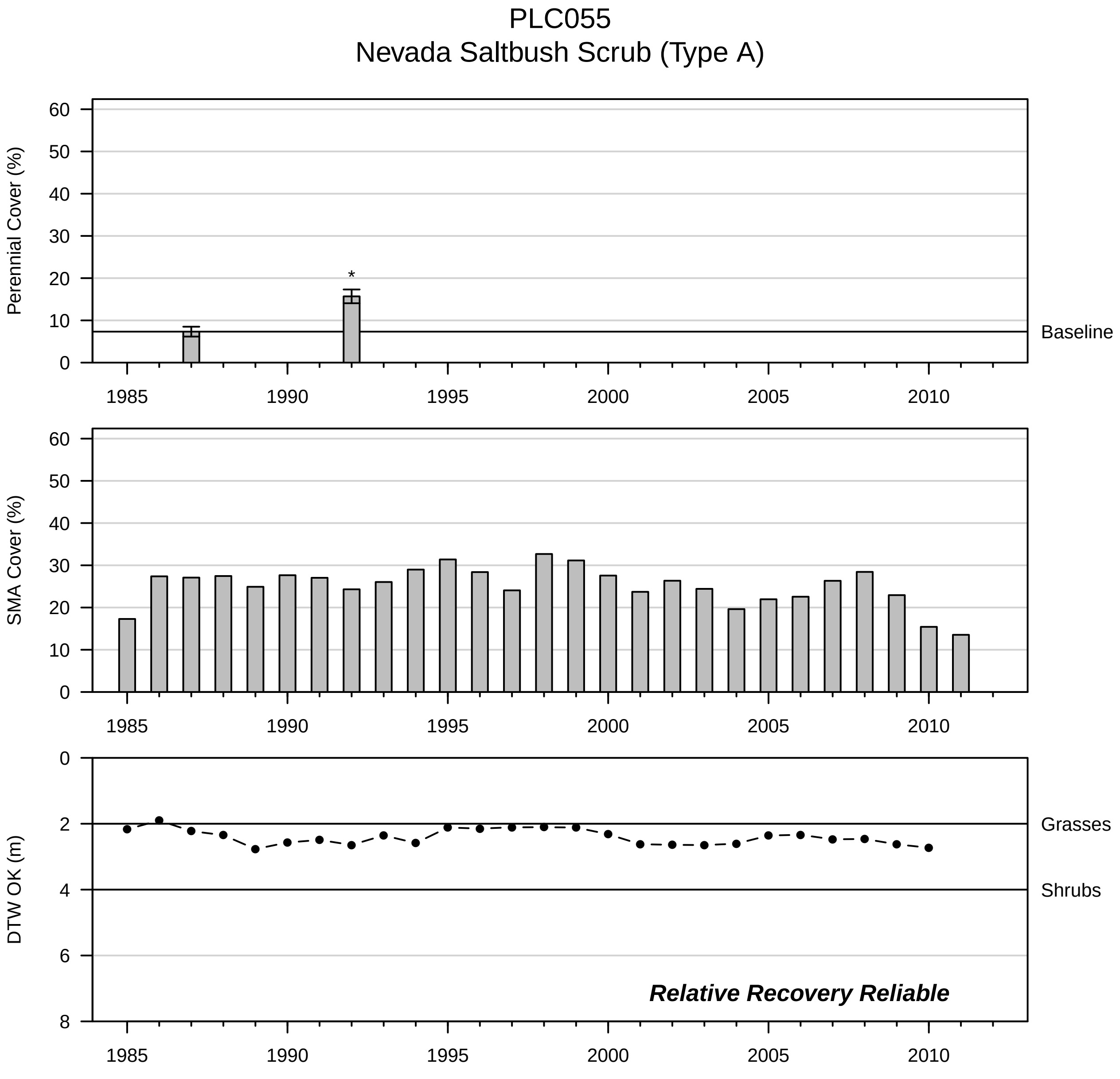


Figure 126: 1992 Control

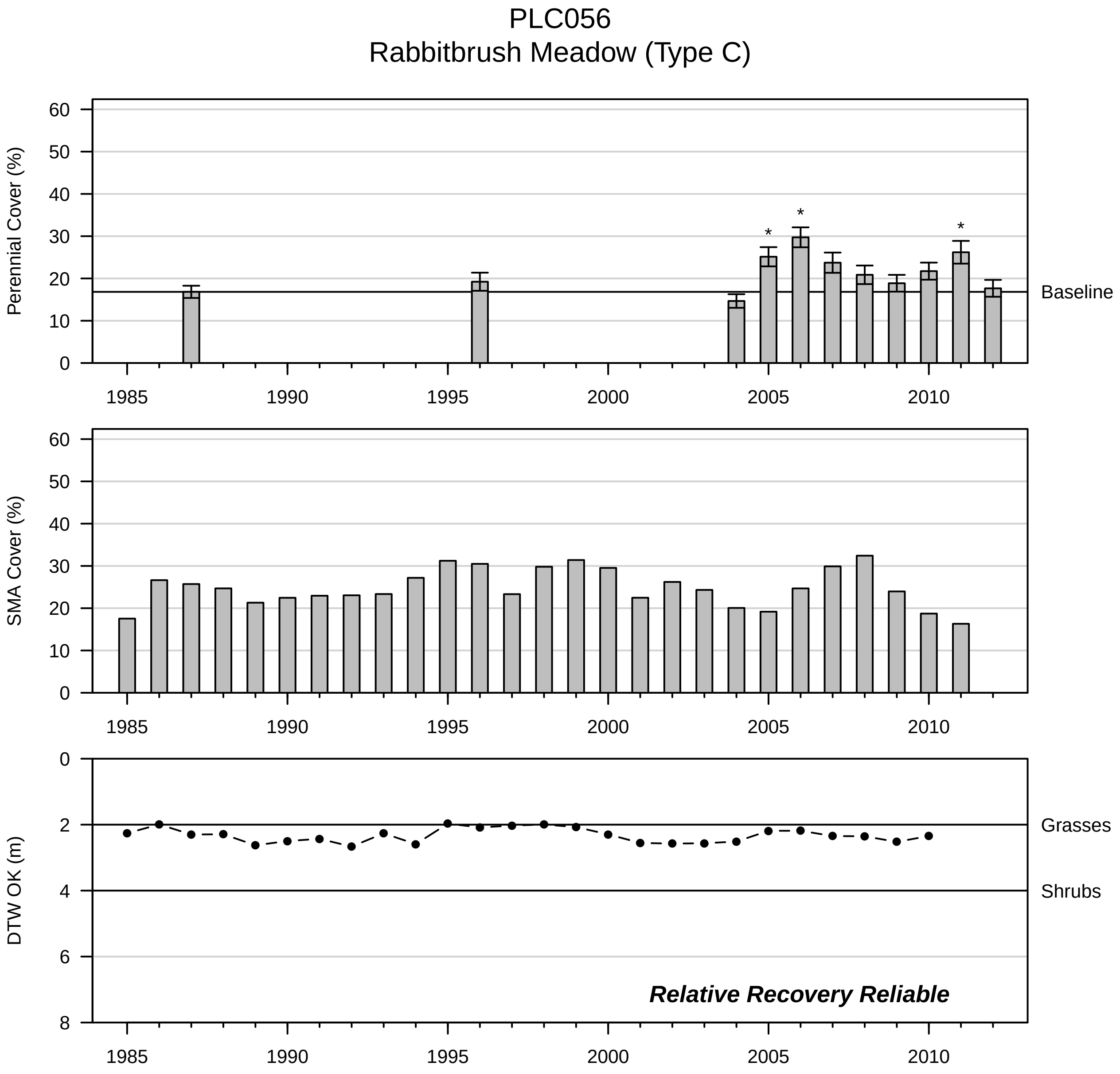
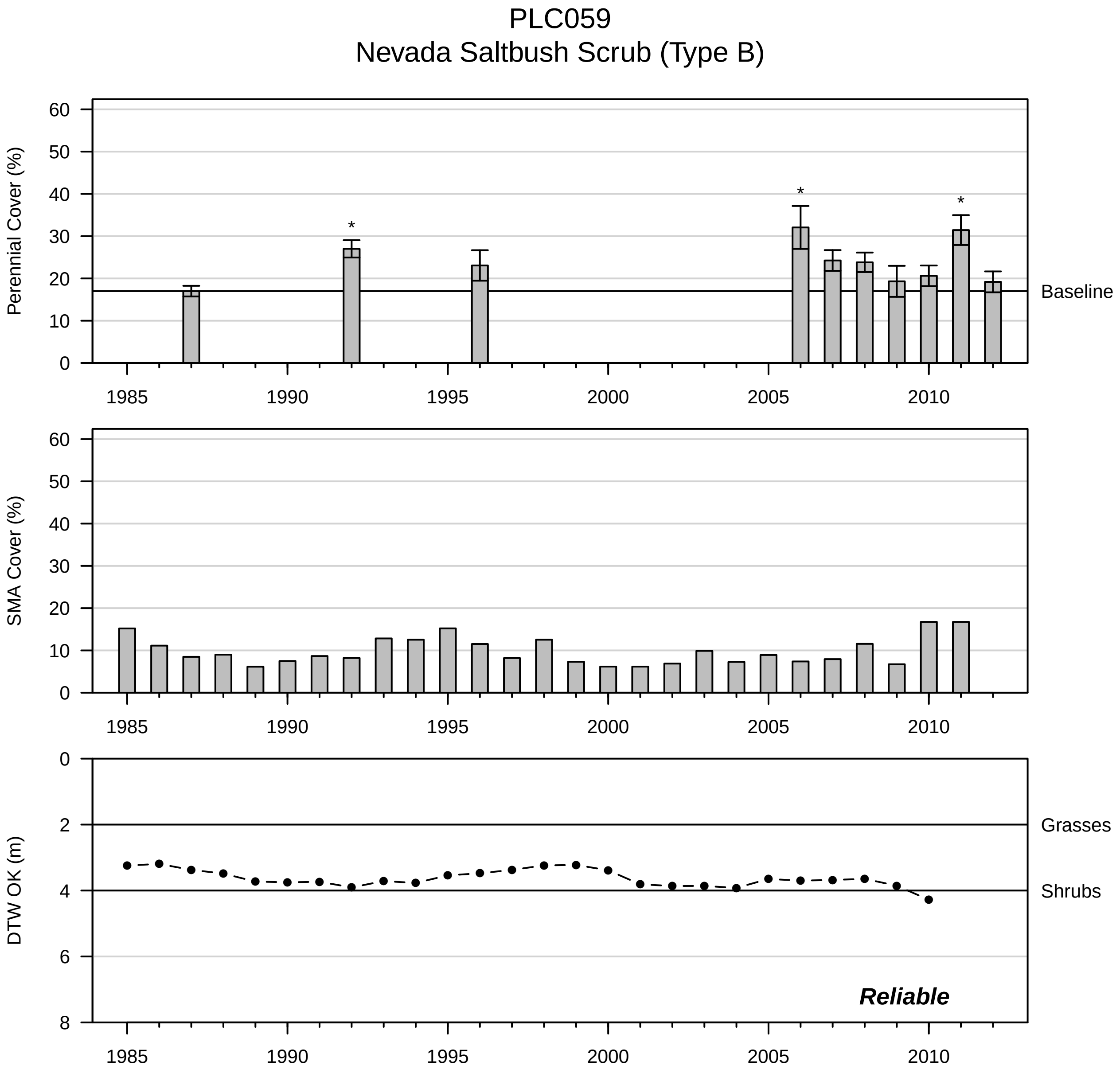


Figure 127: 2012 Control



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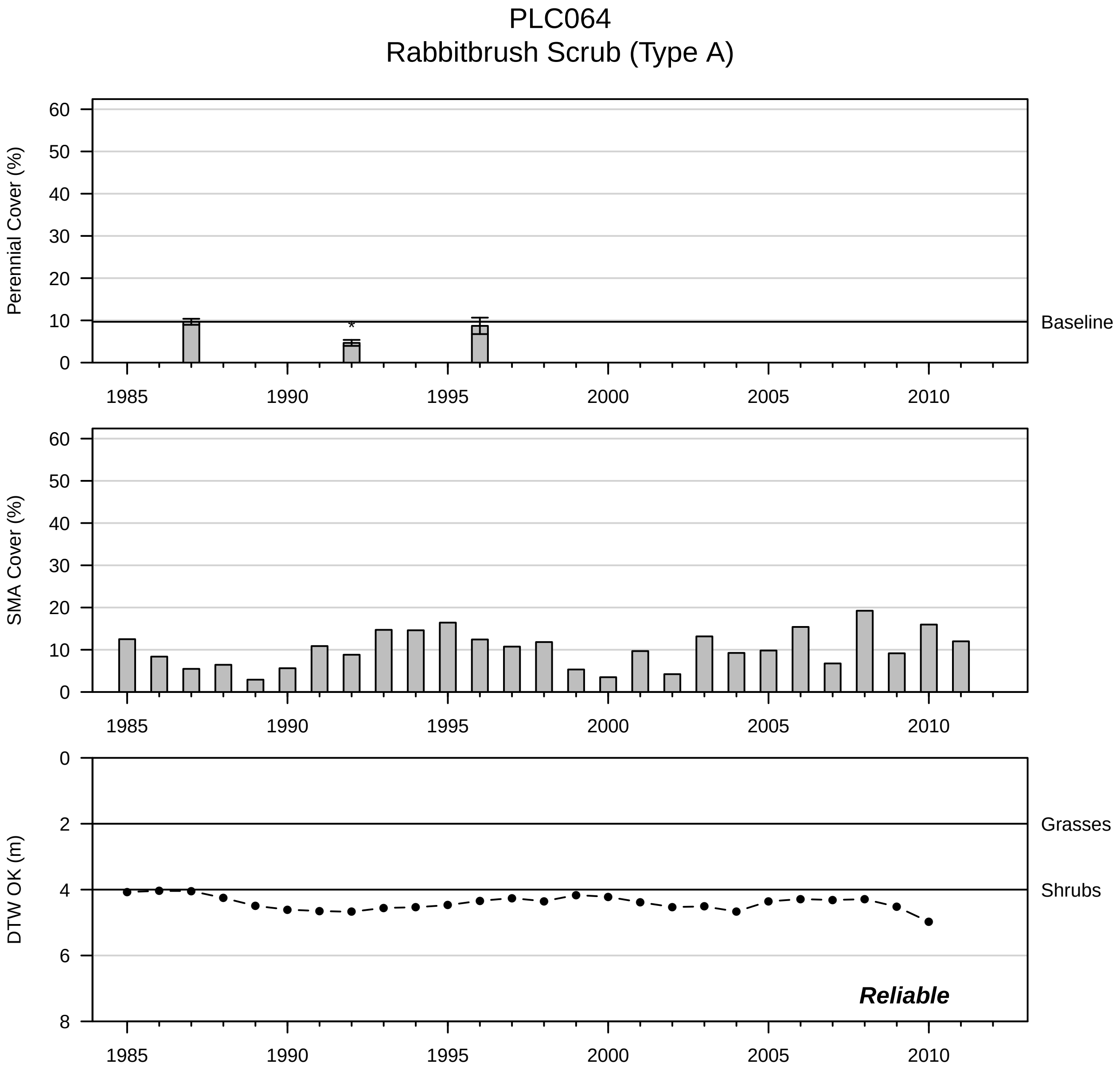


Figure 129: 1996 Control

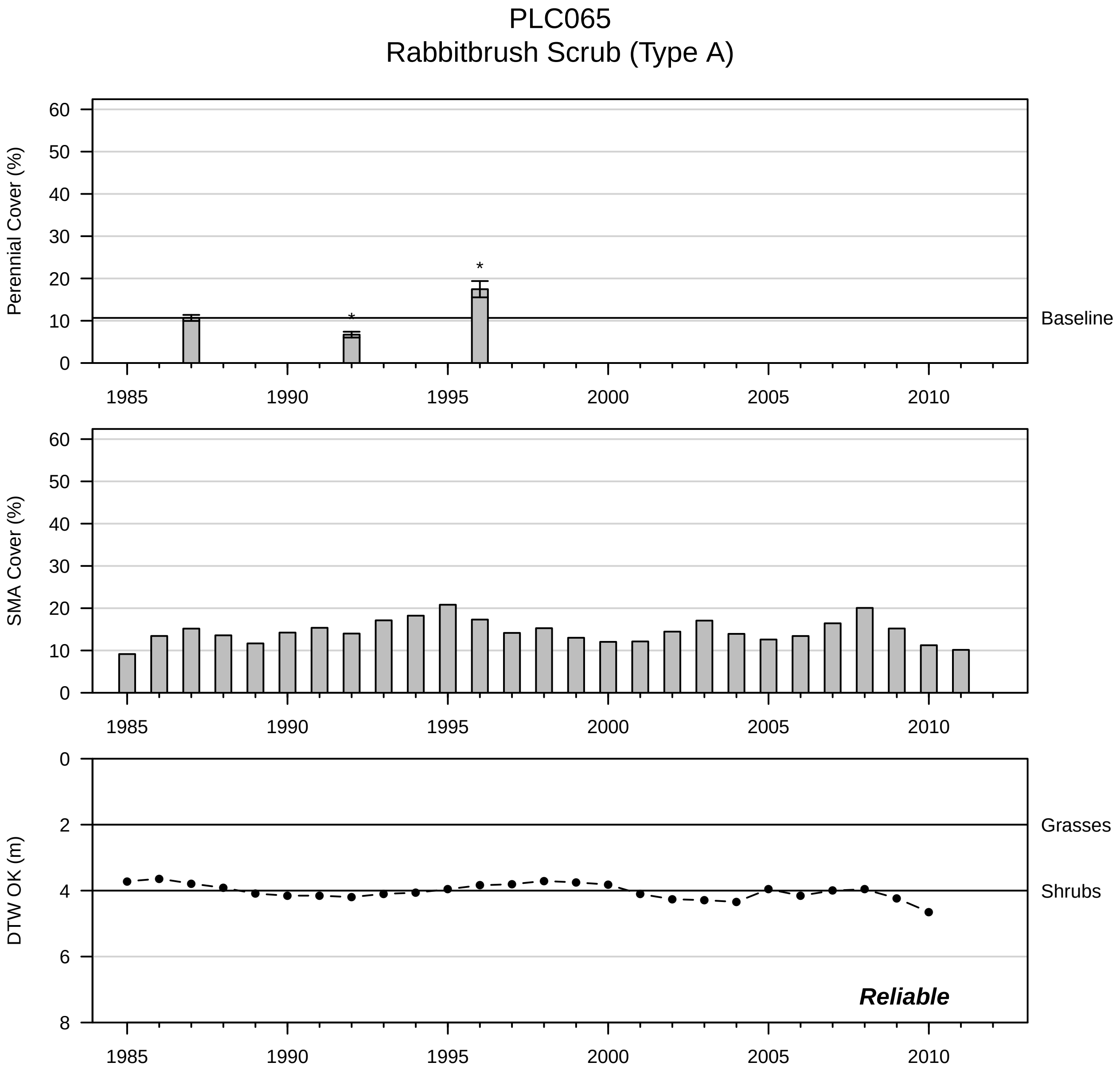


Figure 130: 1996 Control

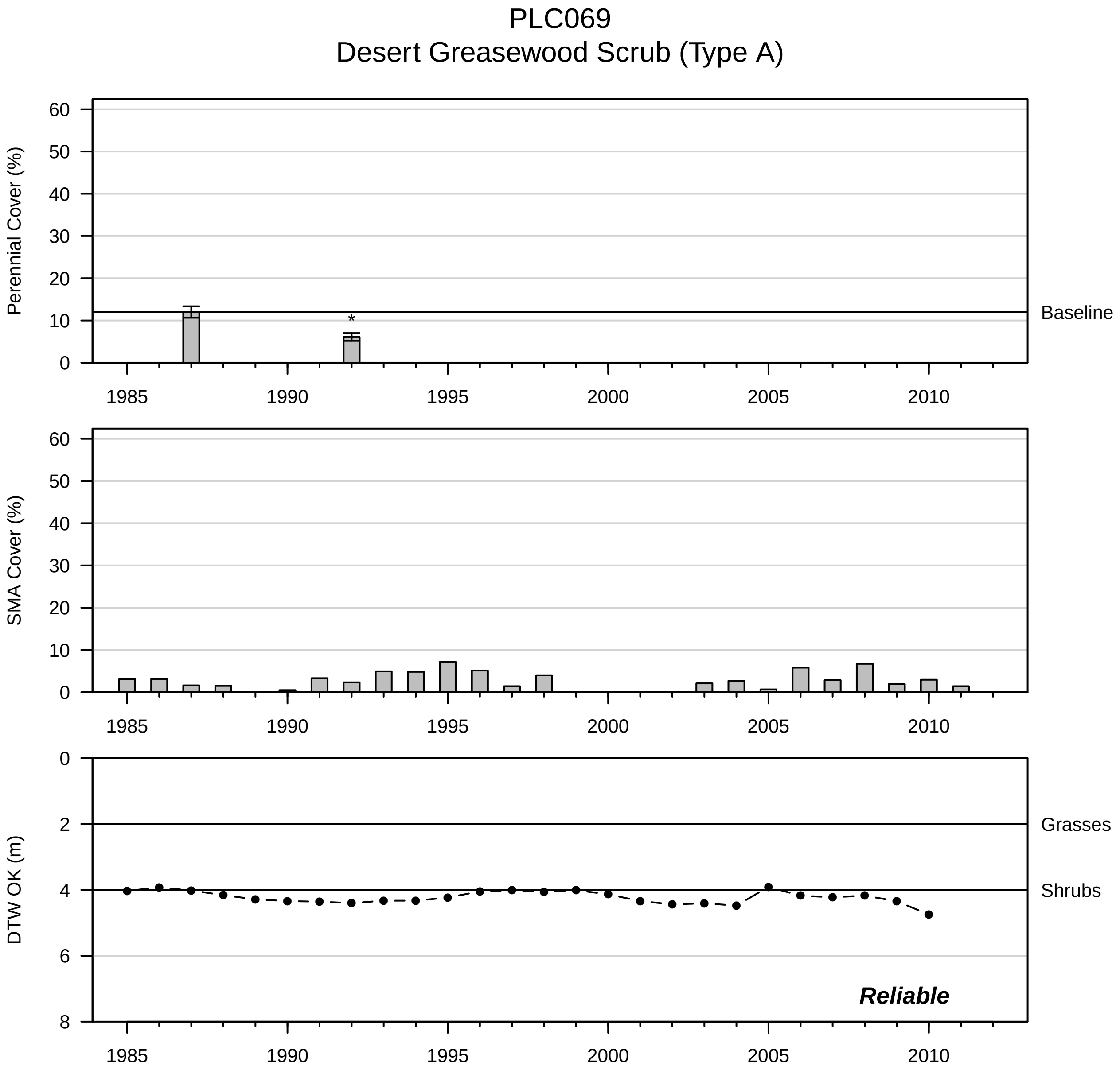


Figure 131: 1992 Control

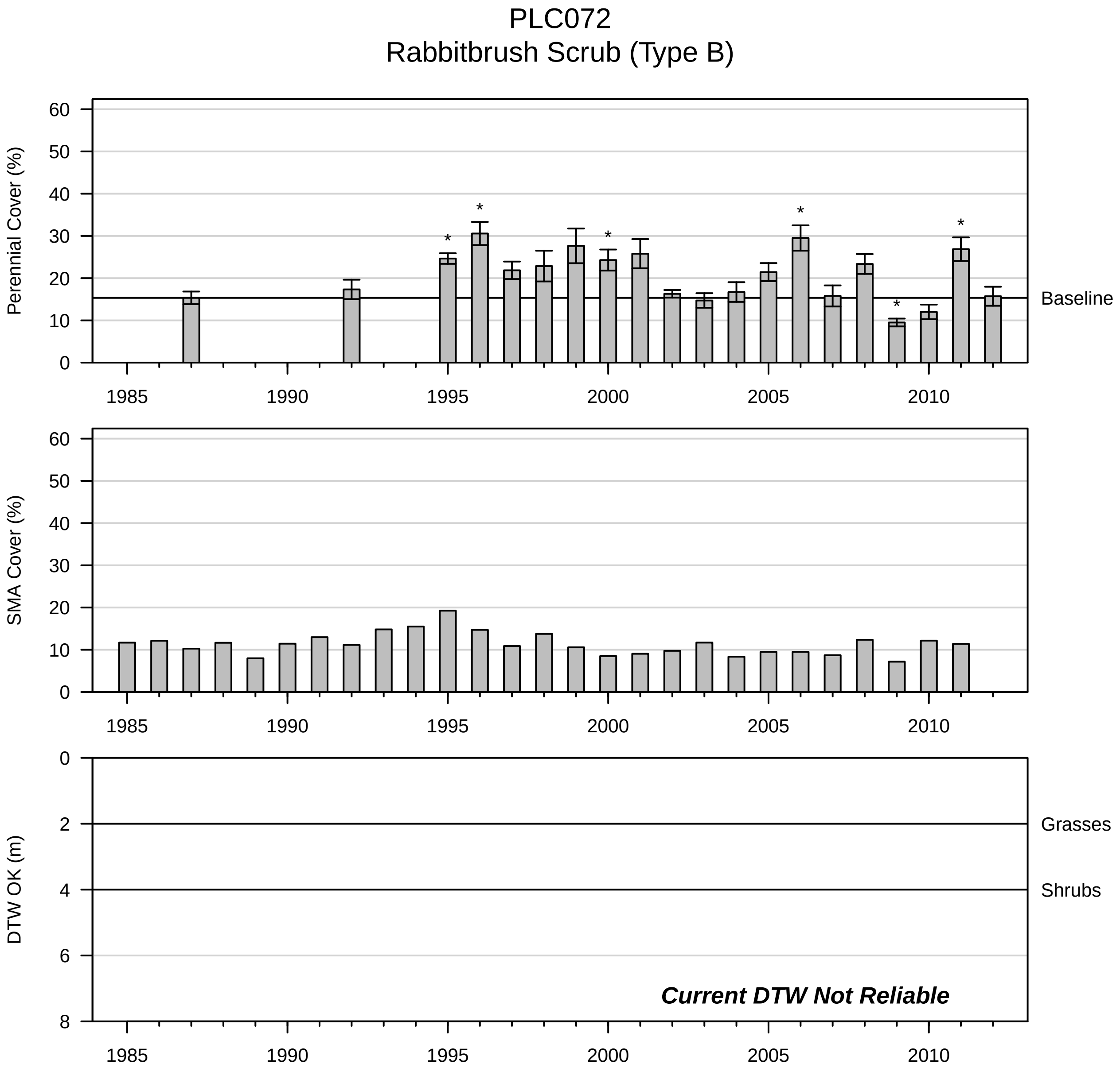


Figure 132: 2012 Control

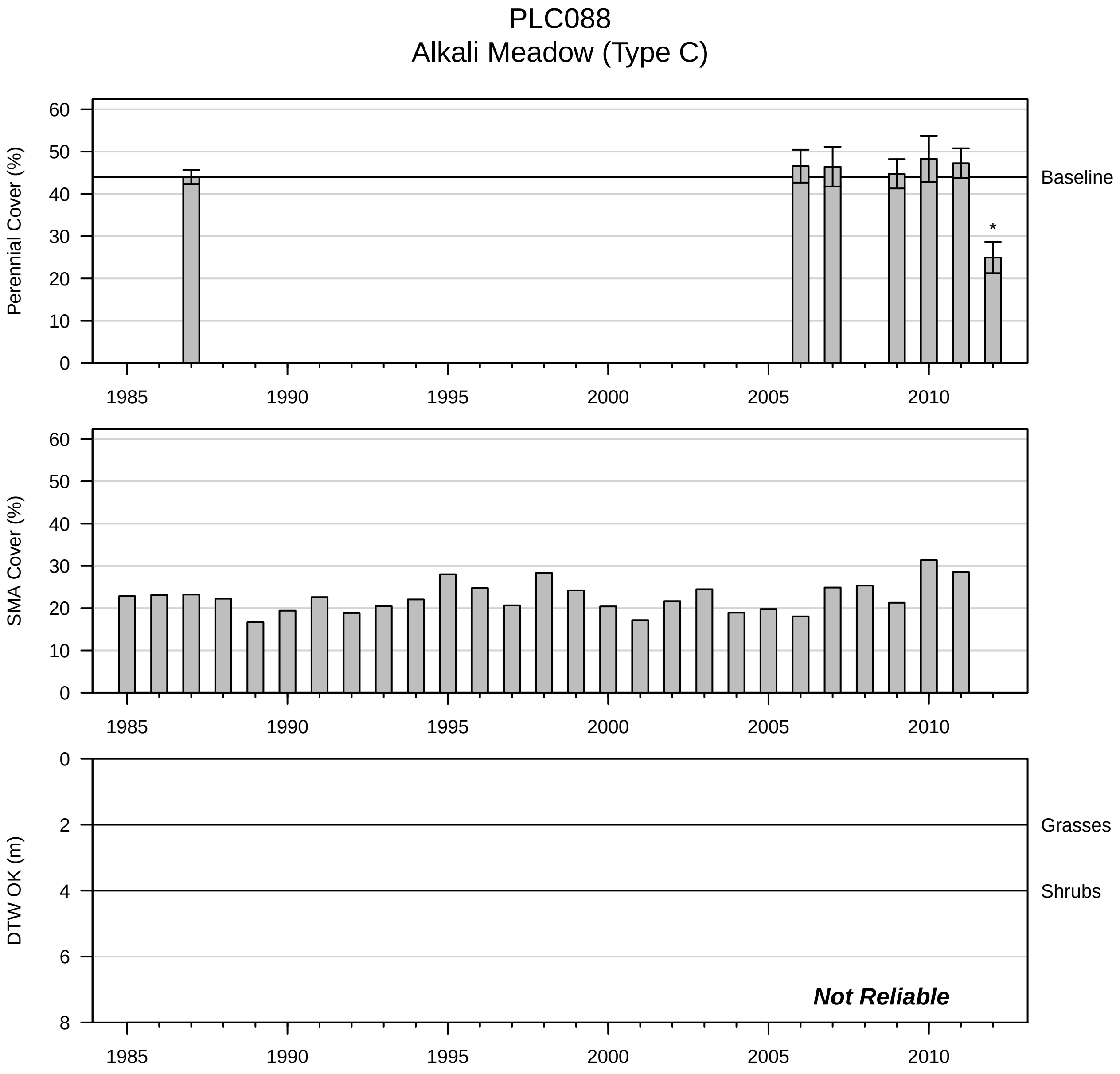
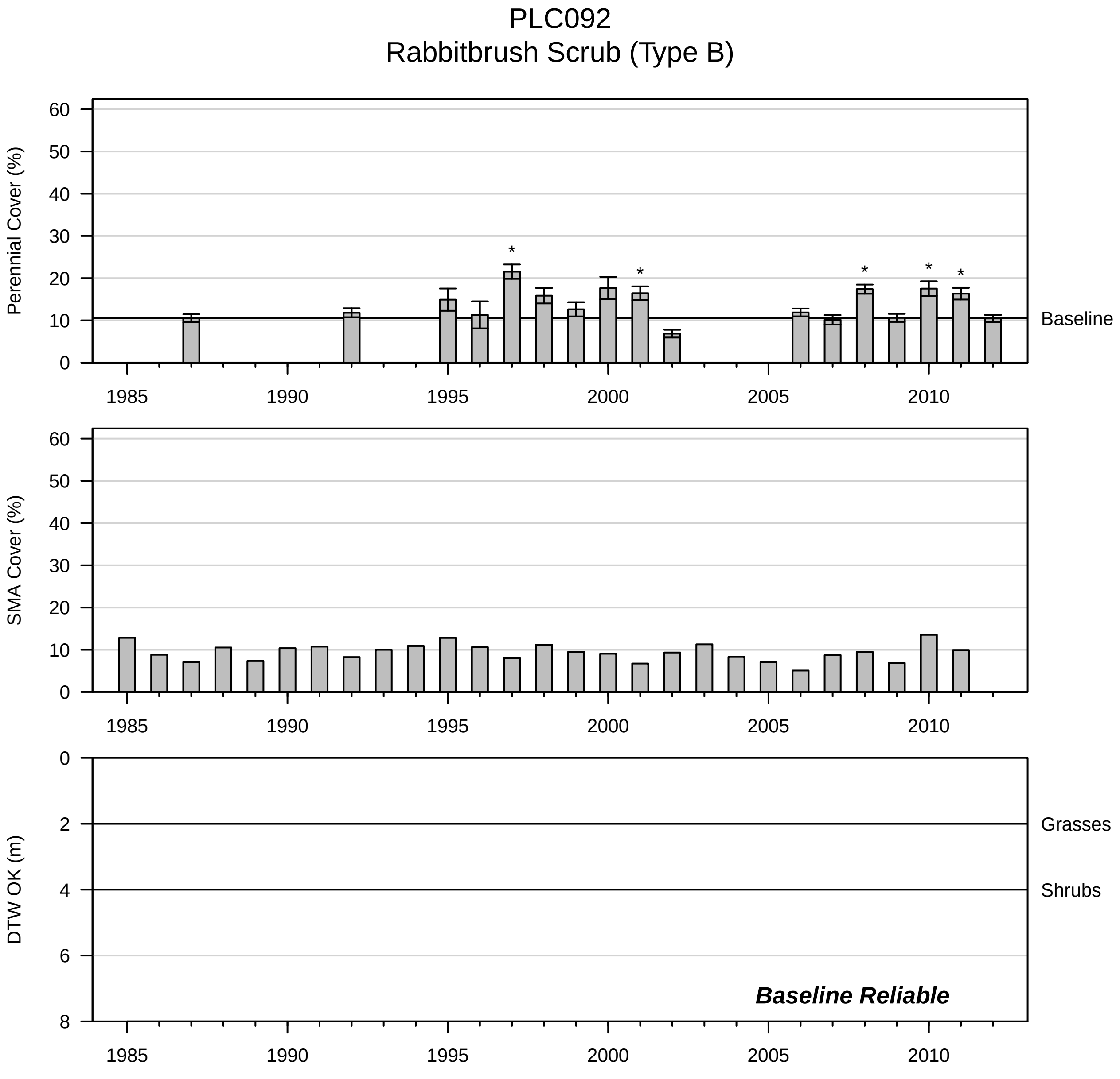


Figure 133: 2012 Control



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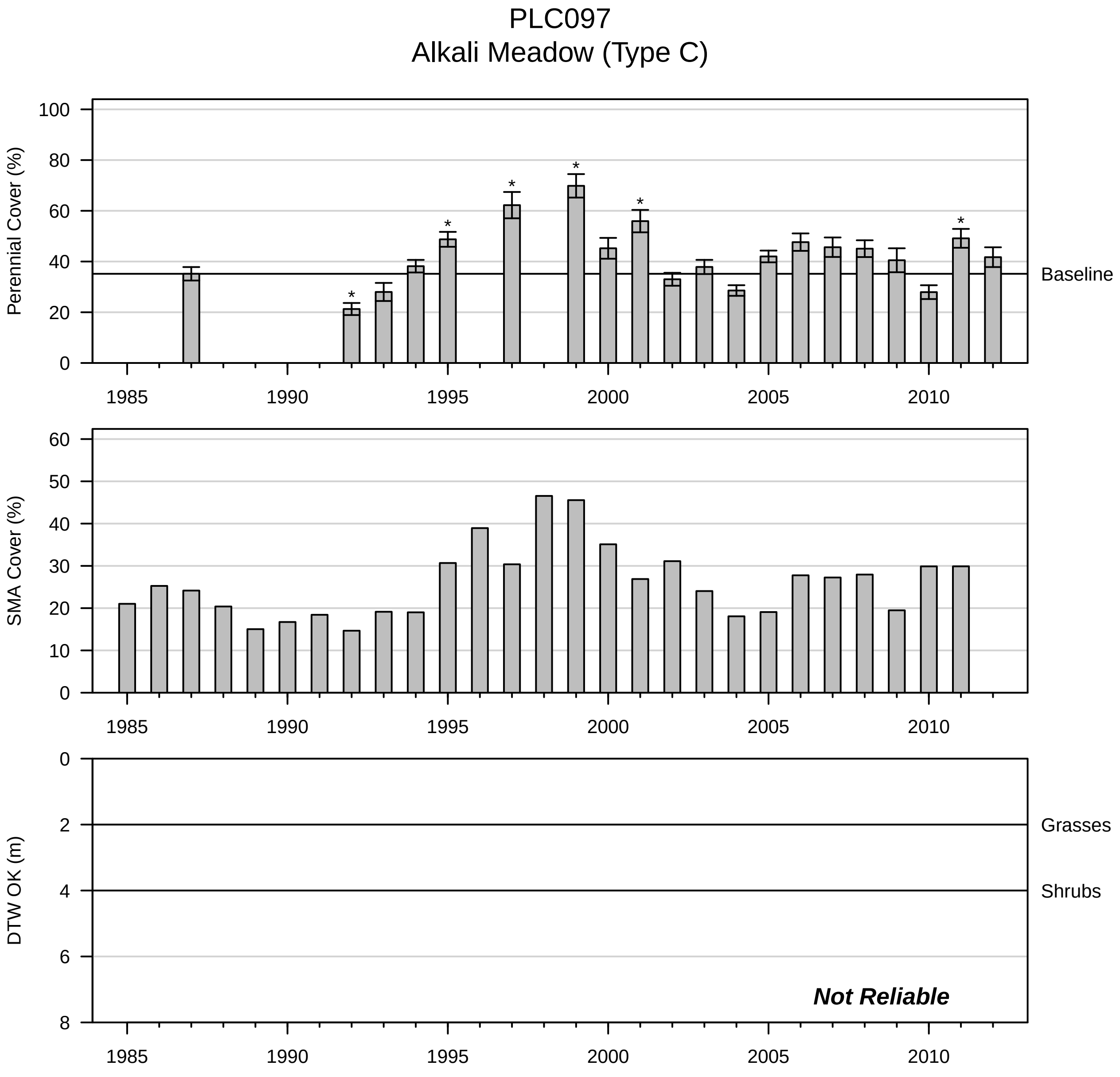


Figure 135: 2012 Control

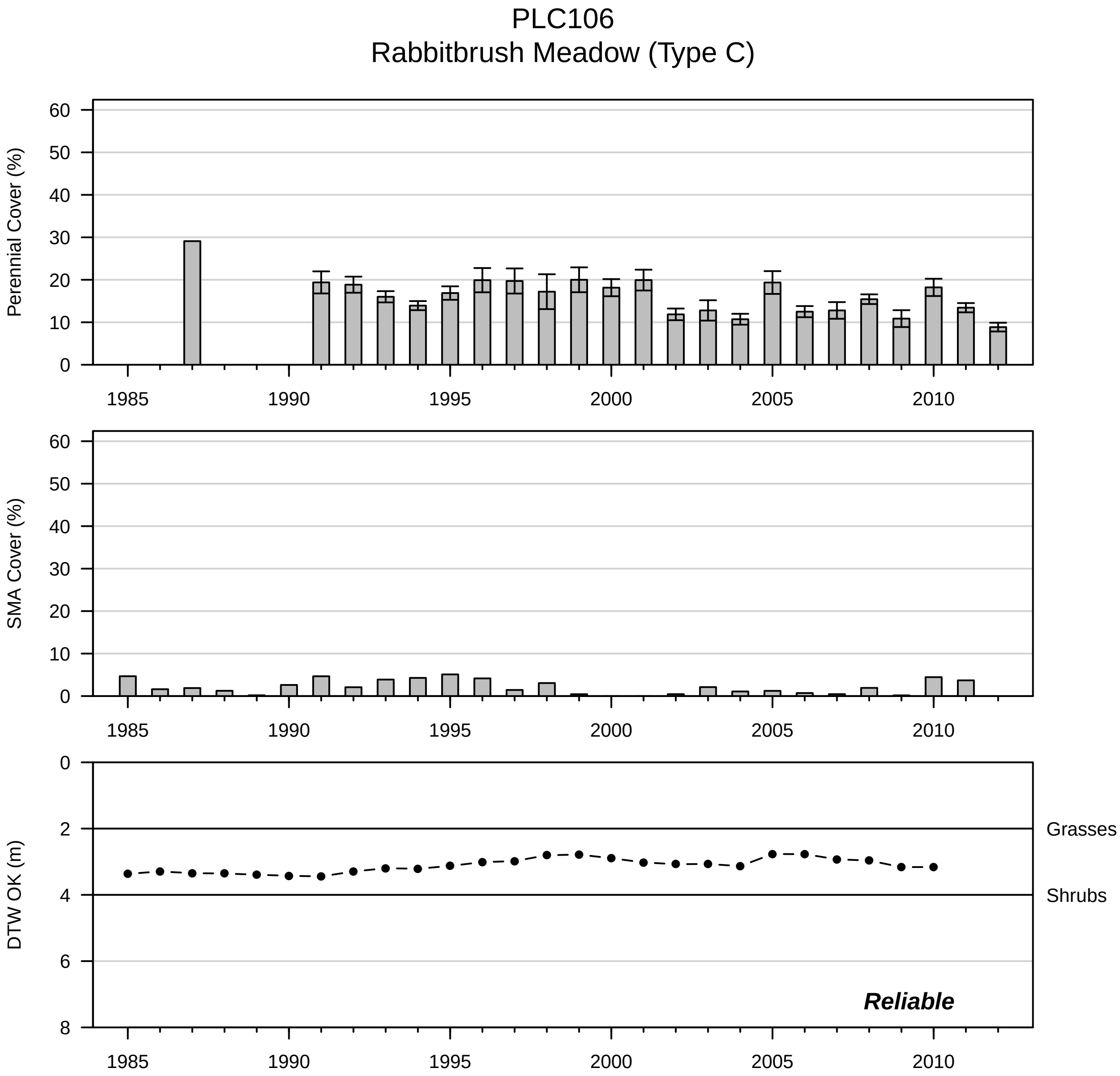


Figure 136: 2012 Control

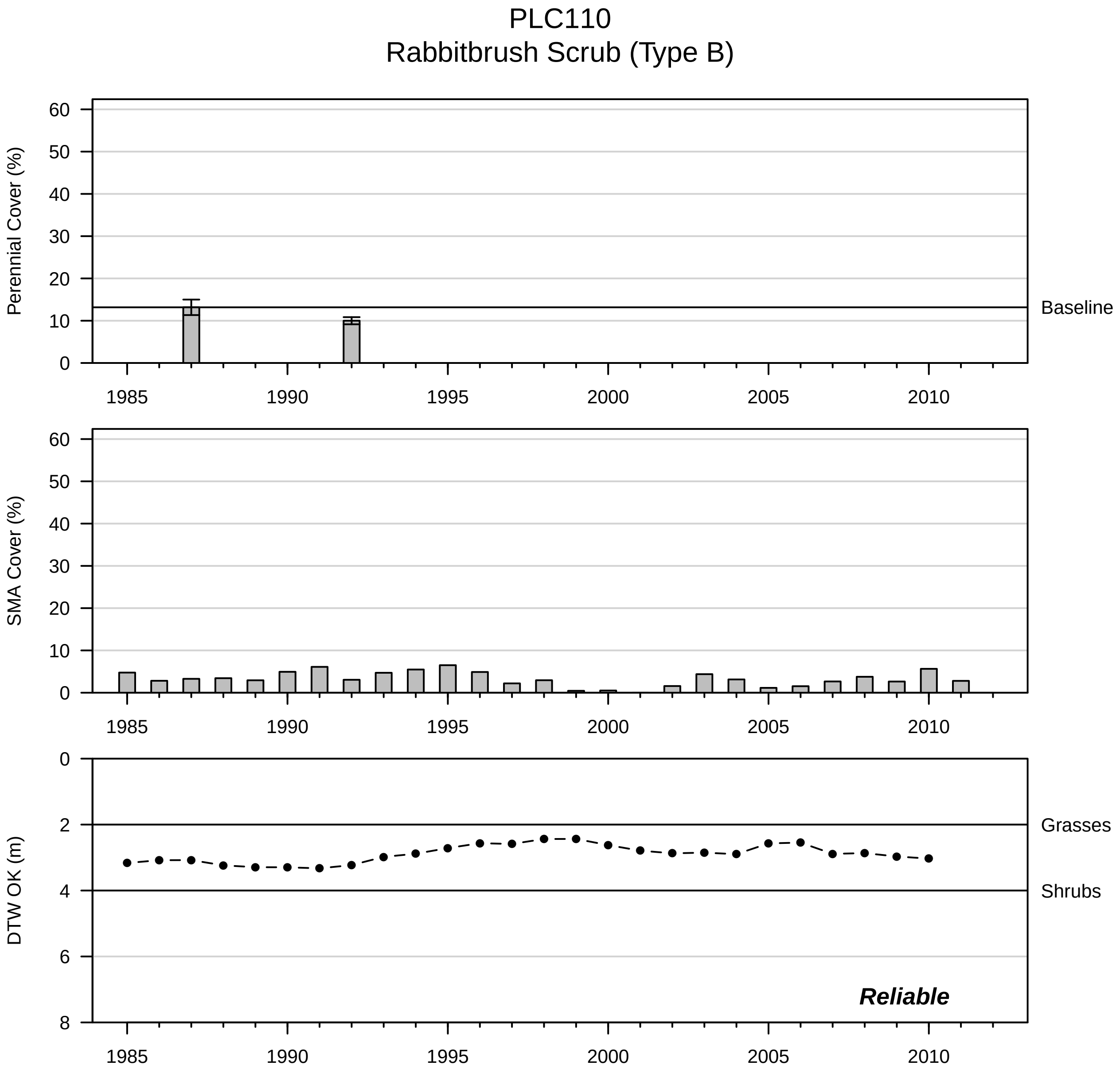


Figure 137: 1992 Control

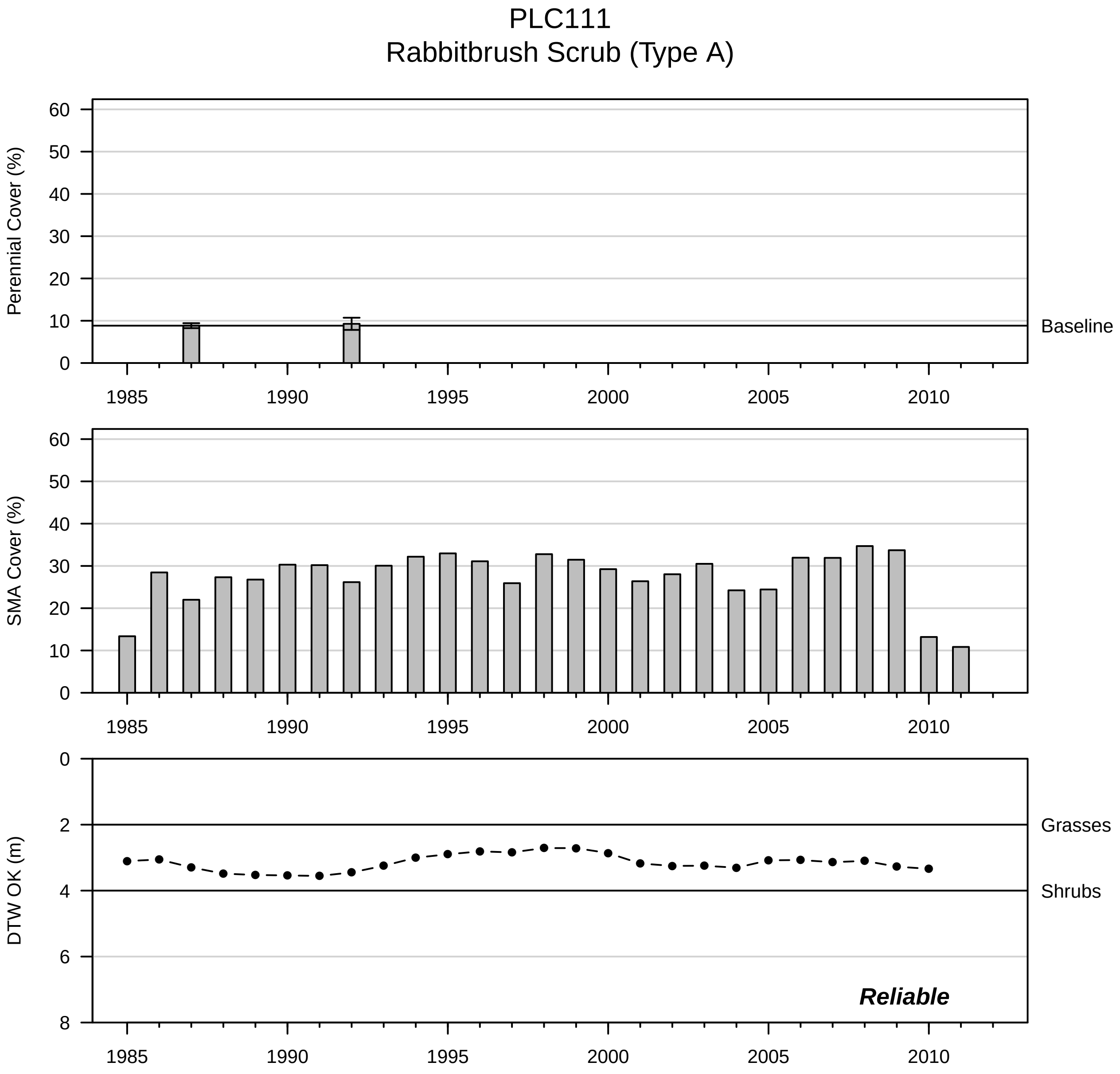


Figure 138: 1992 Control

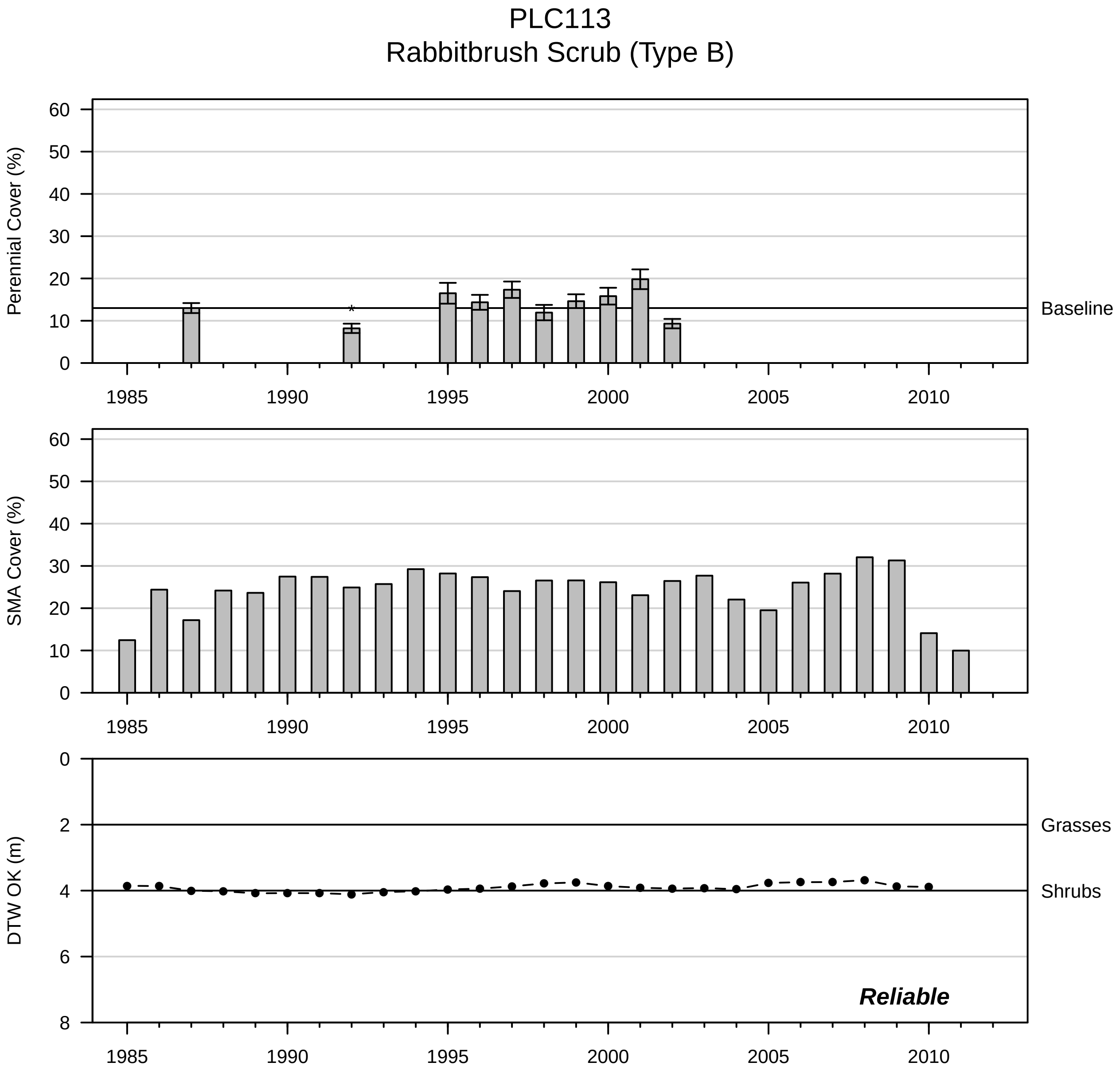


Figure 139: 2002 Control

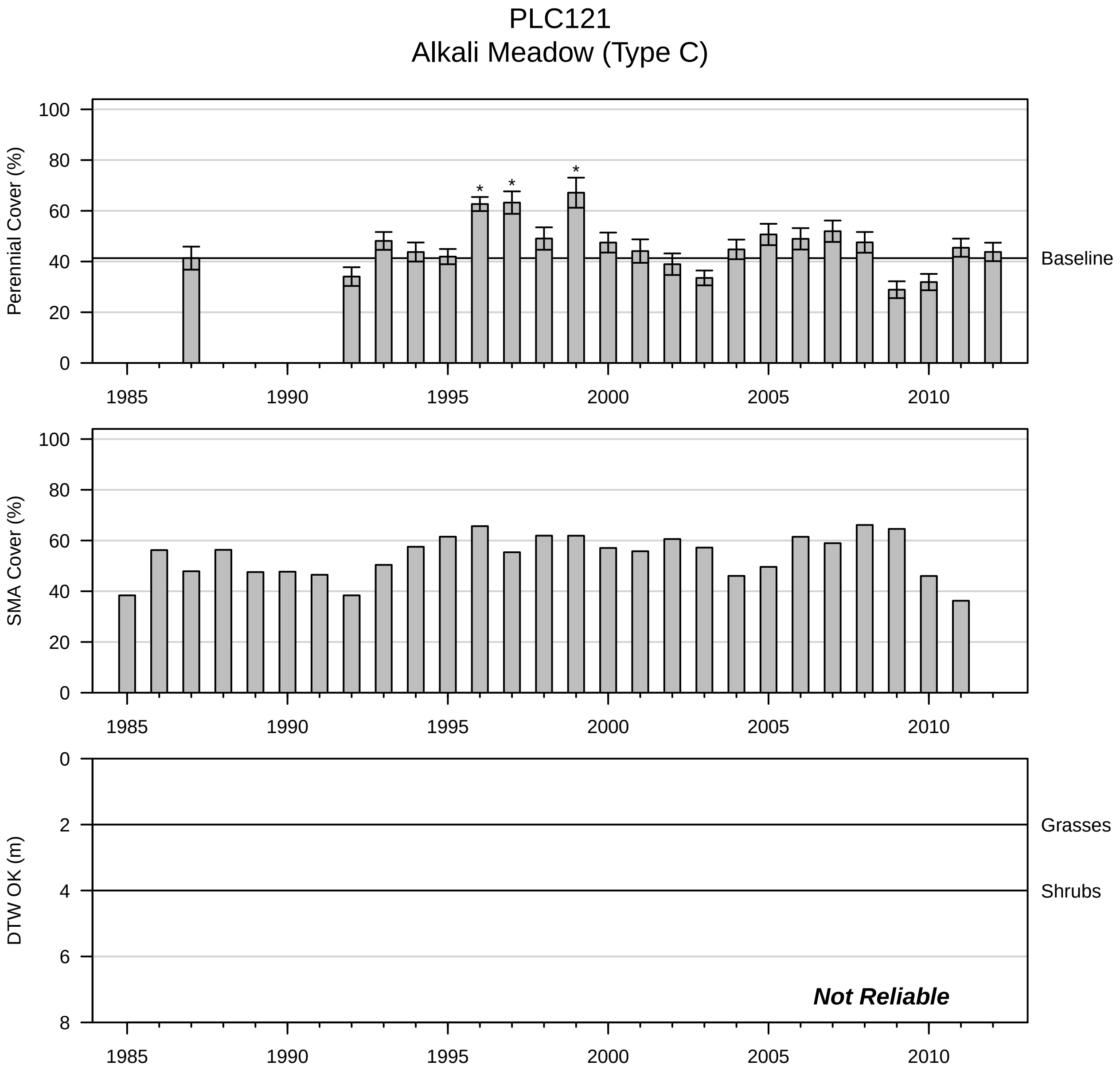


Figure 140: 2012 Control

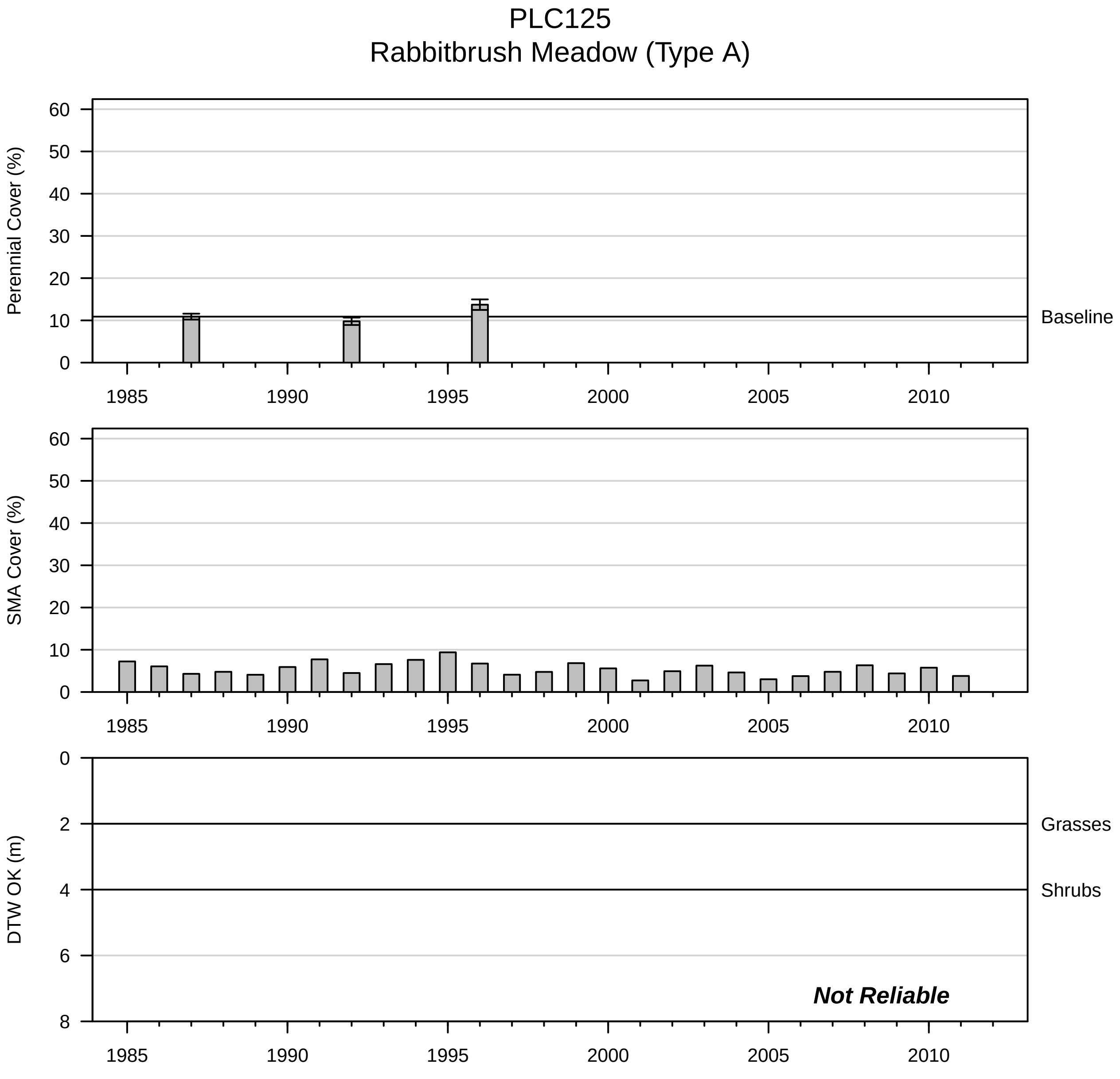


Figure 141: 1996 Control

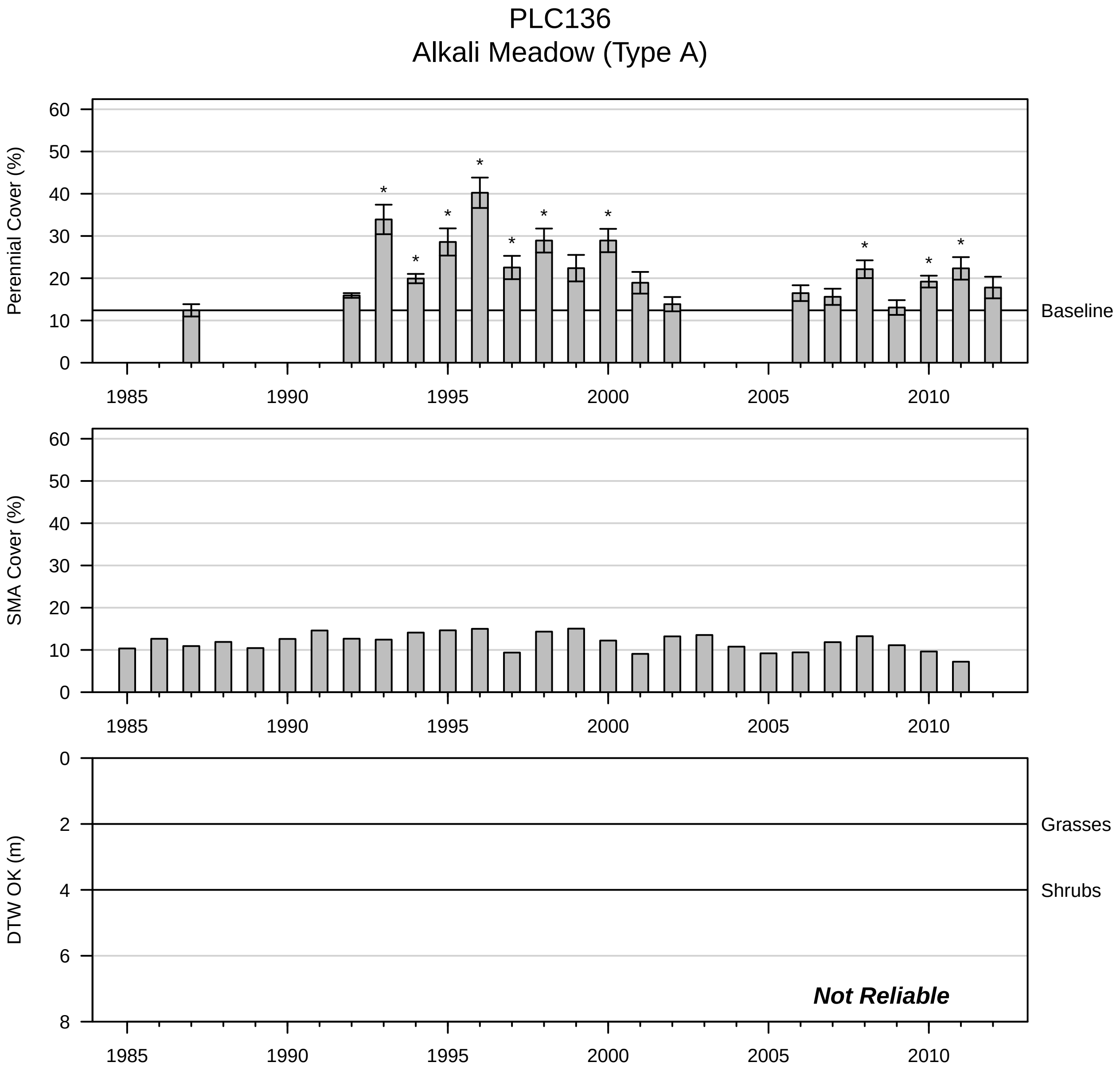


Figure 142: 2012 Control

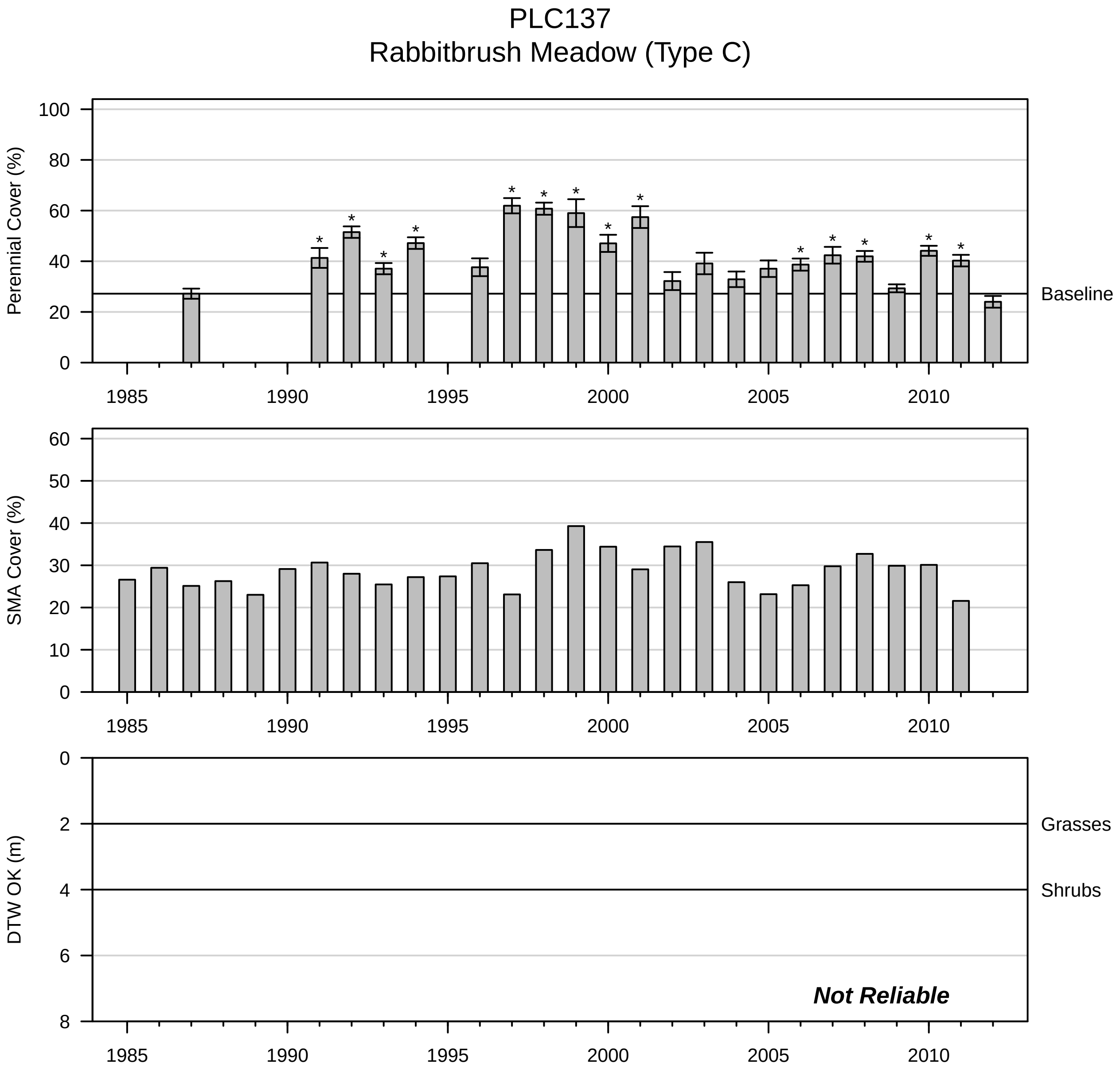


Figure 143: 2012 Control

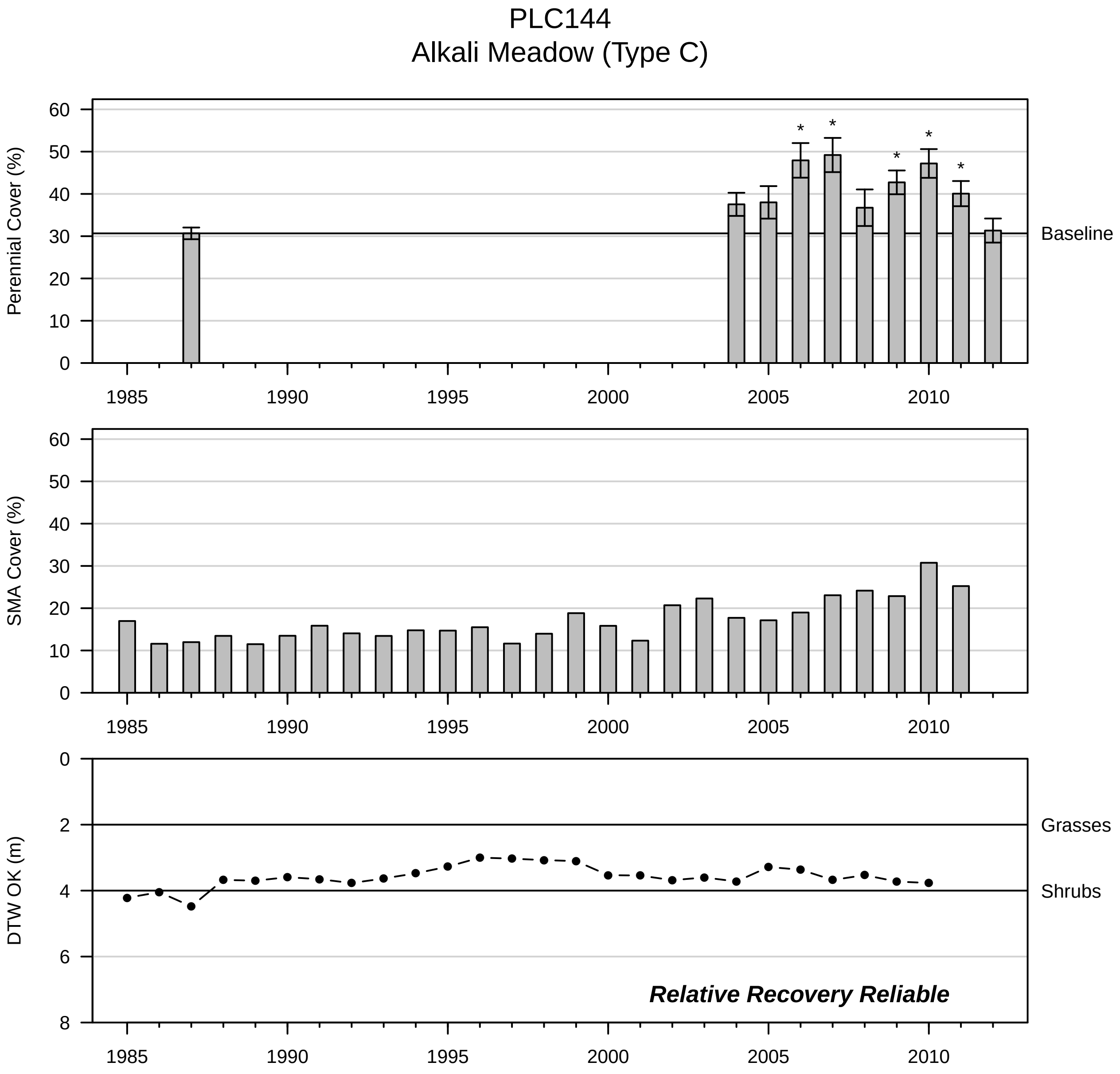


Figure 144: 2012 Control

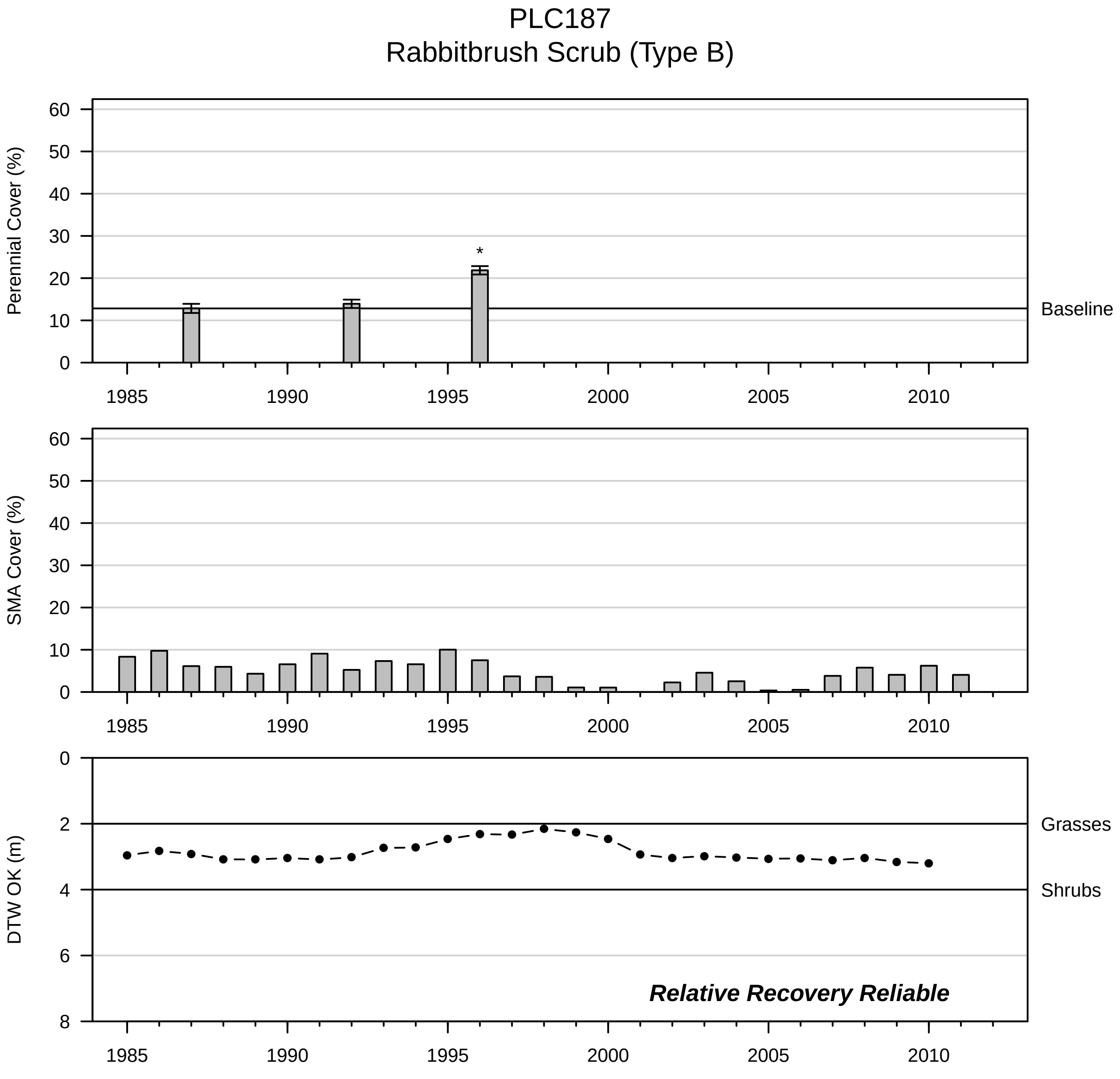


Figure 145: 1996 Control

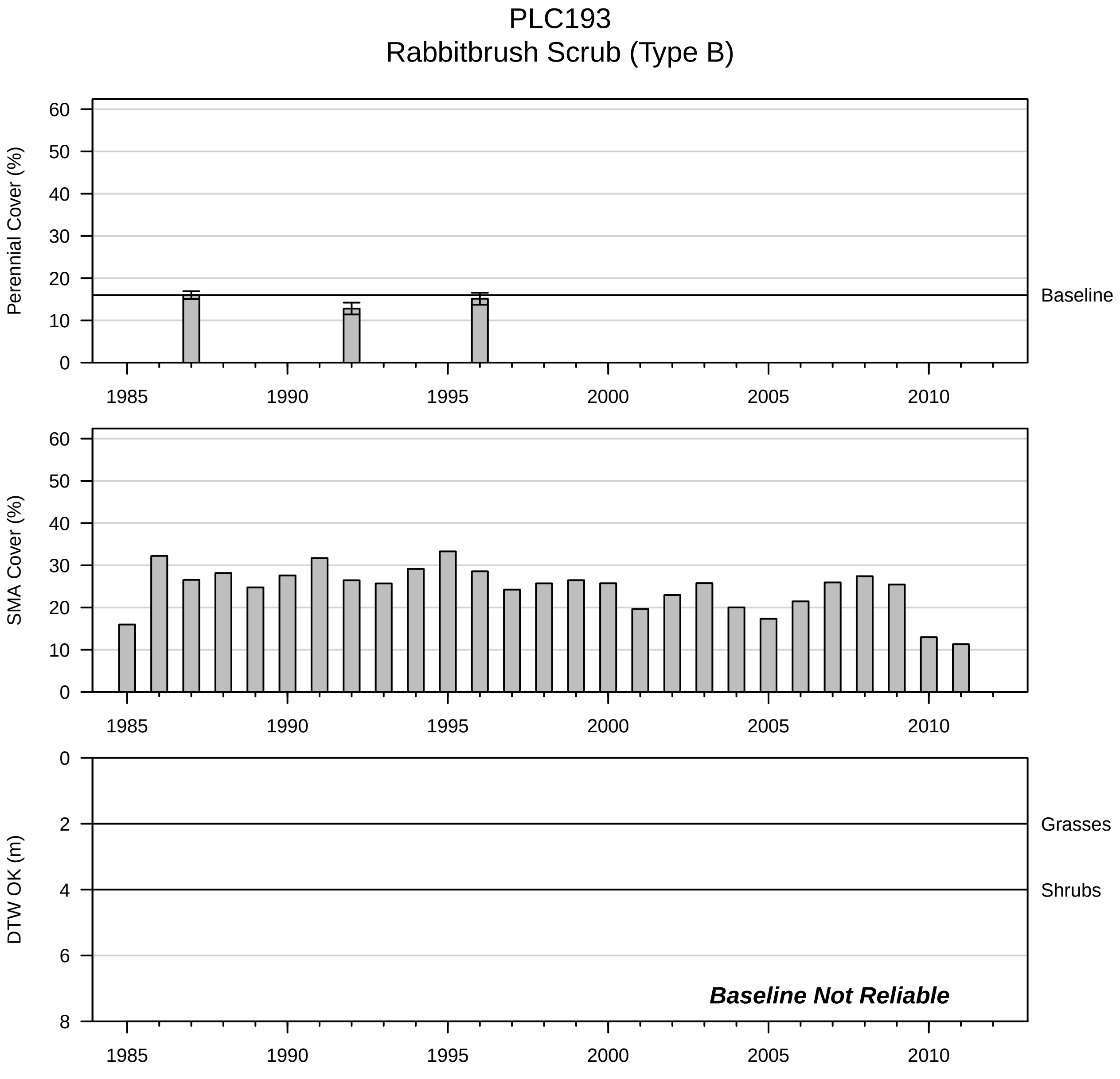


Figure 146: 1996 Control

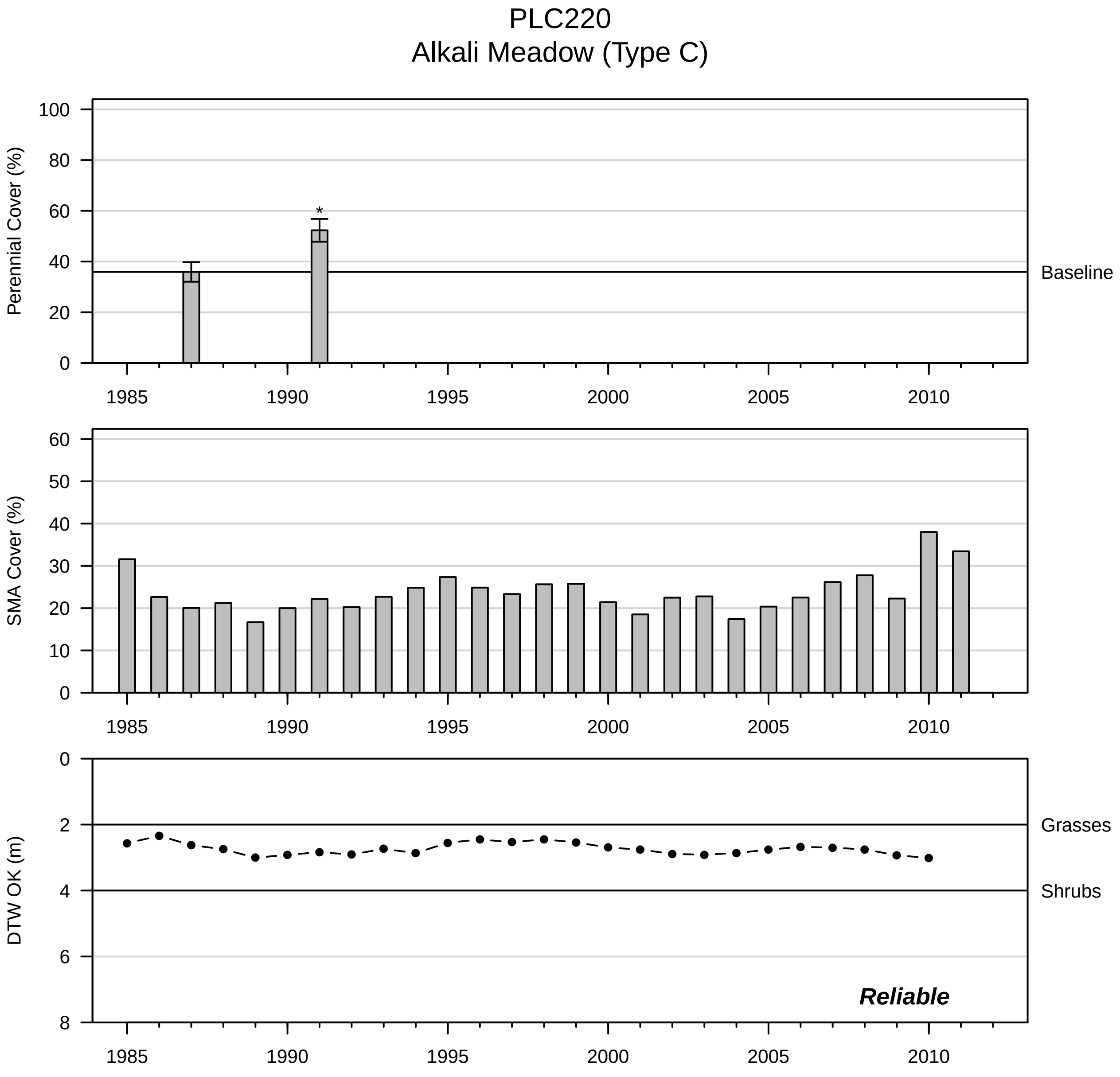
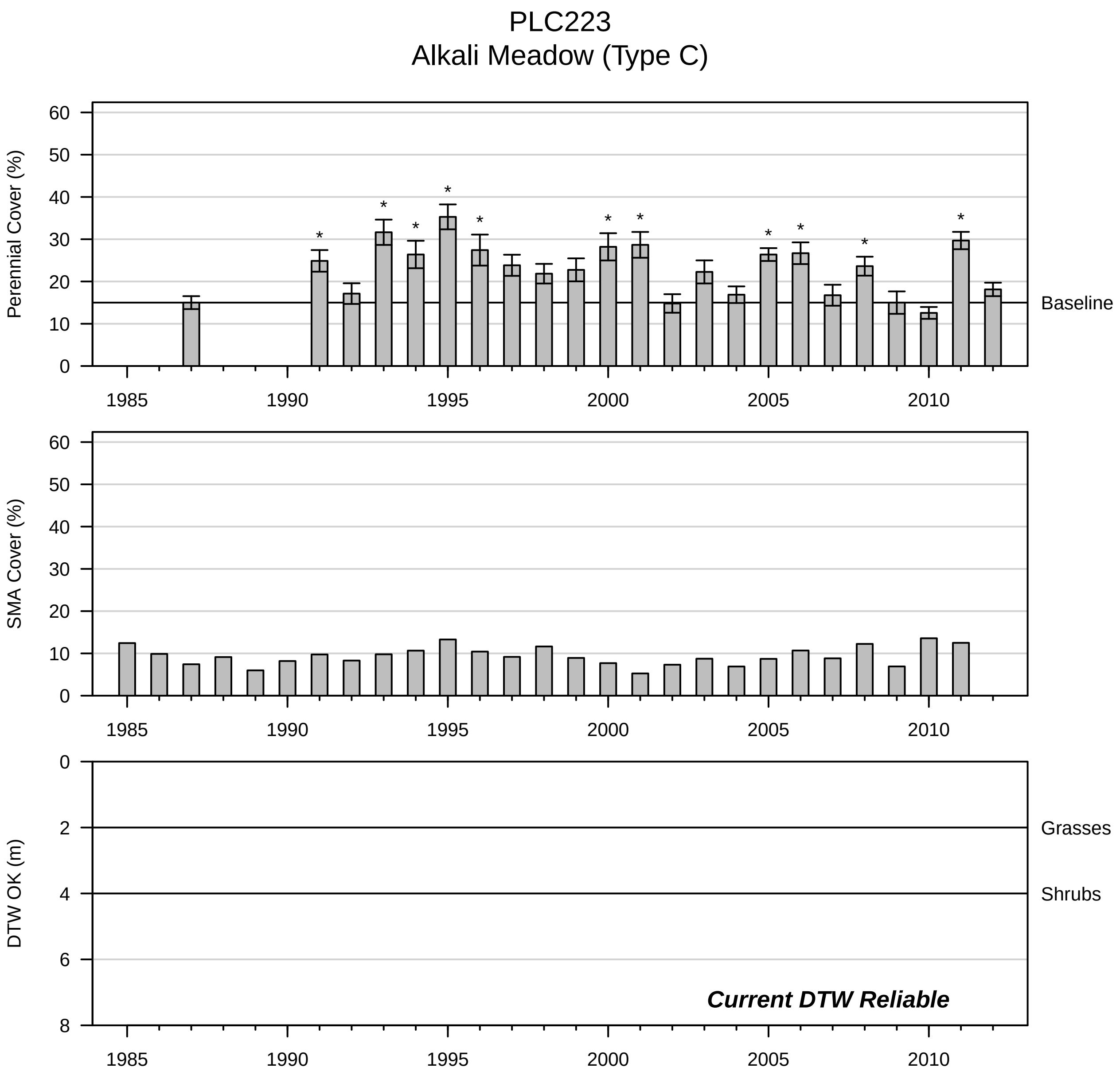


Figure 147: 1991 Control



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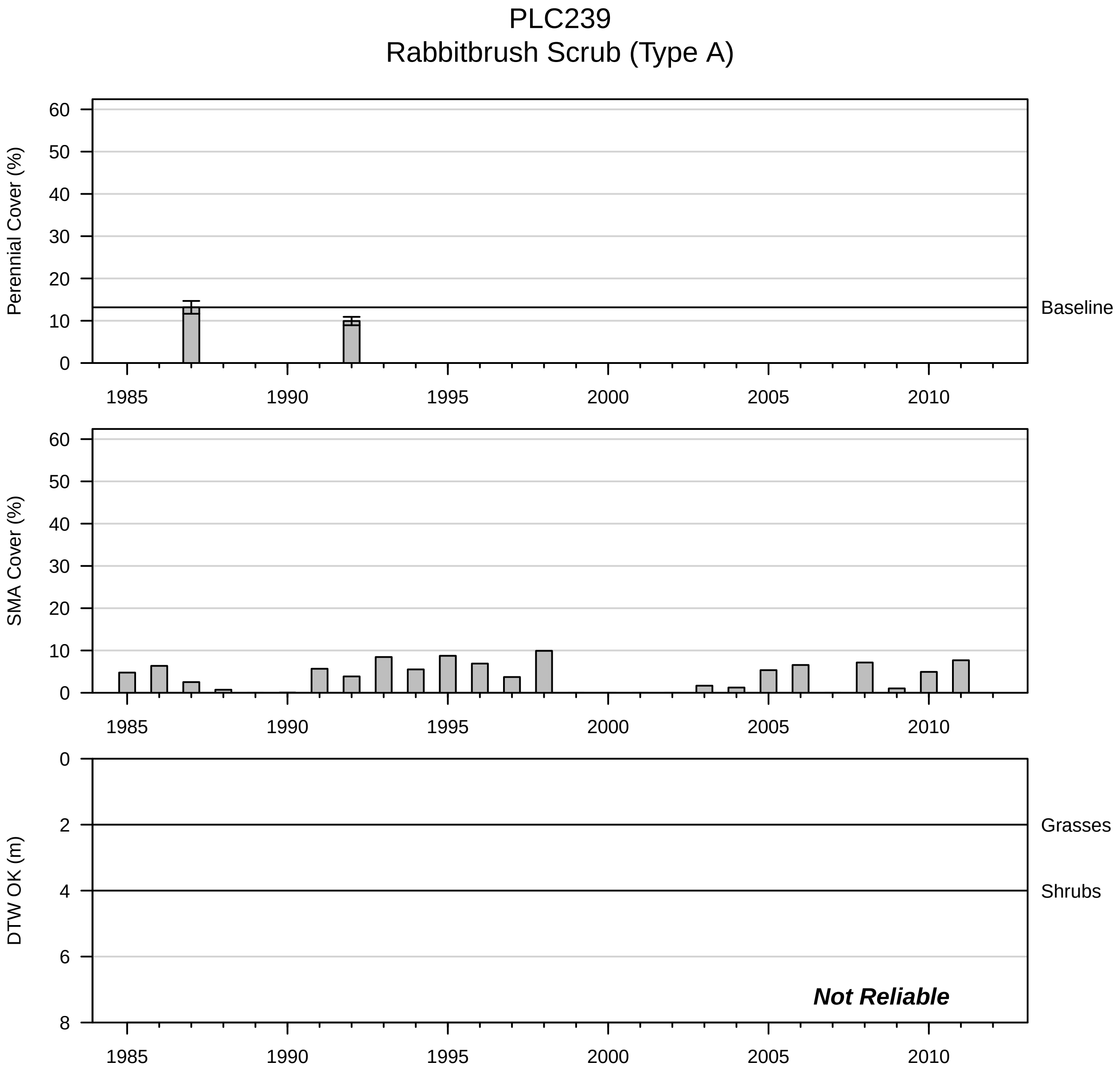

Figure 149: 1992 Control

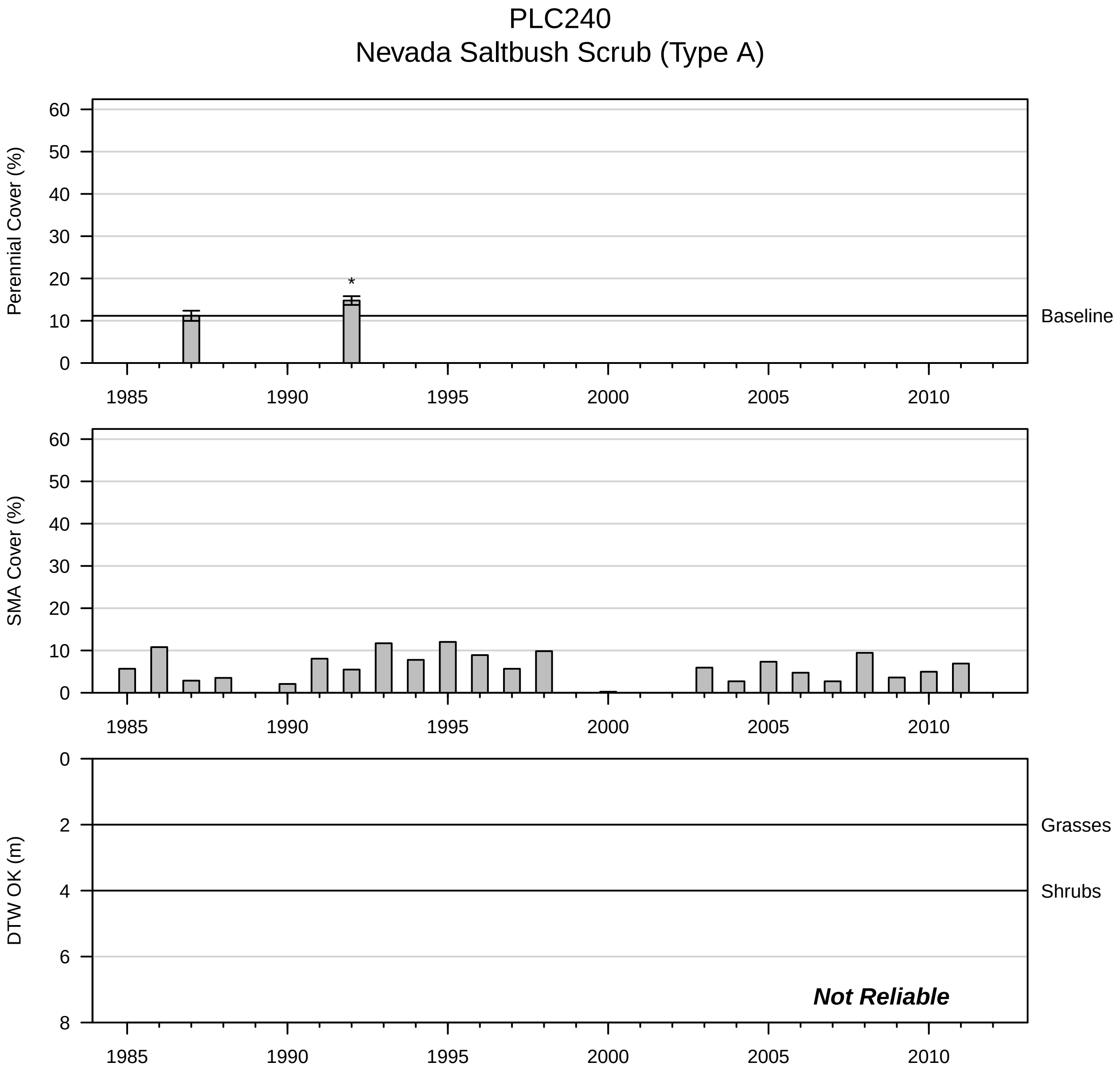

Figure 150: 1992 Control

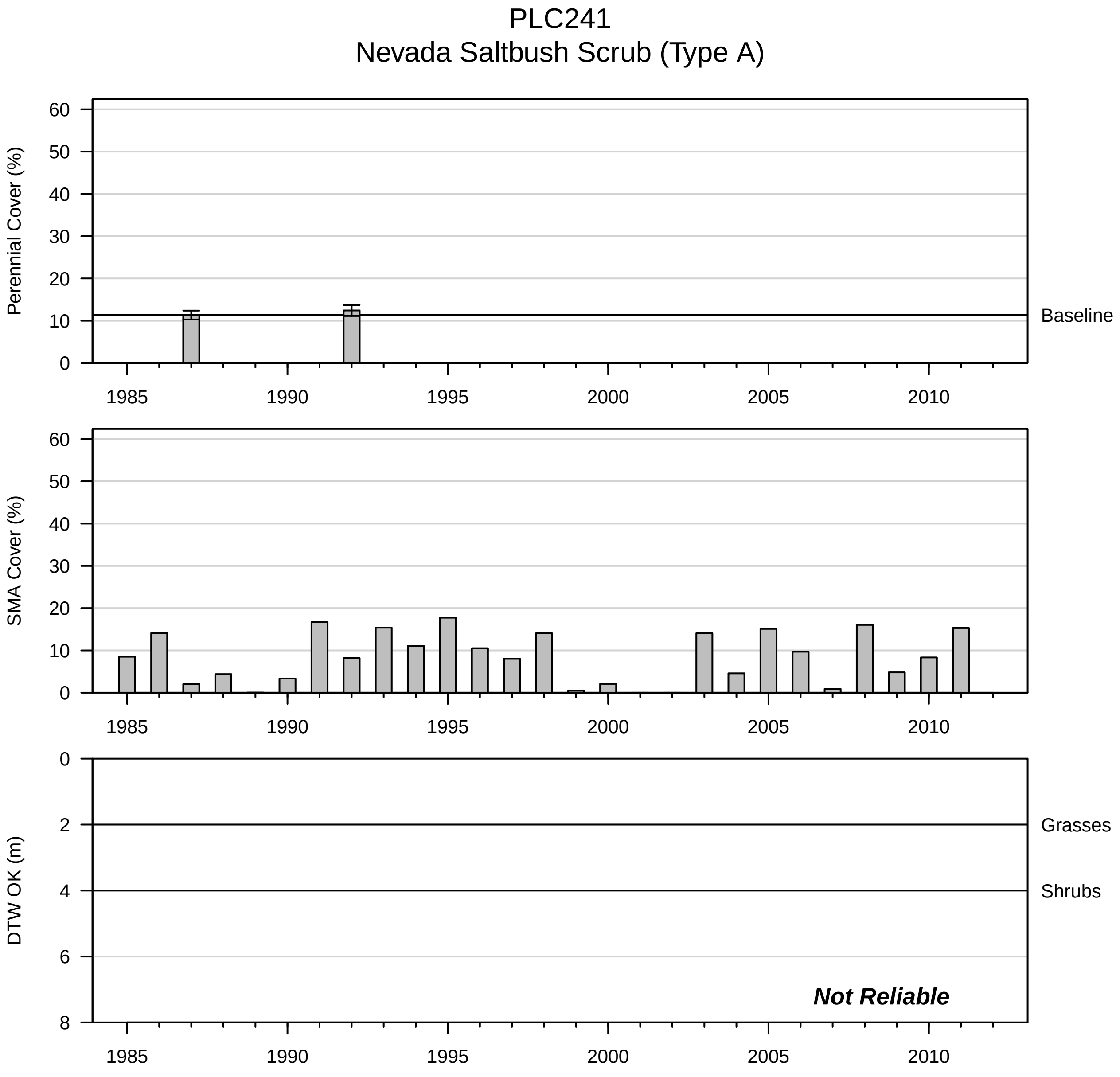

Figure 151: 1992 Control

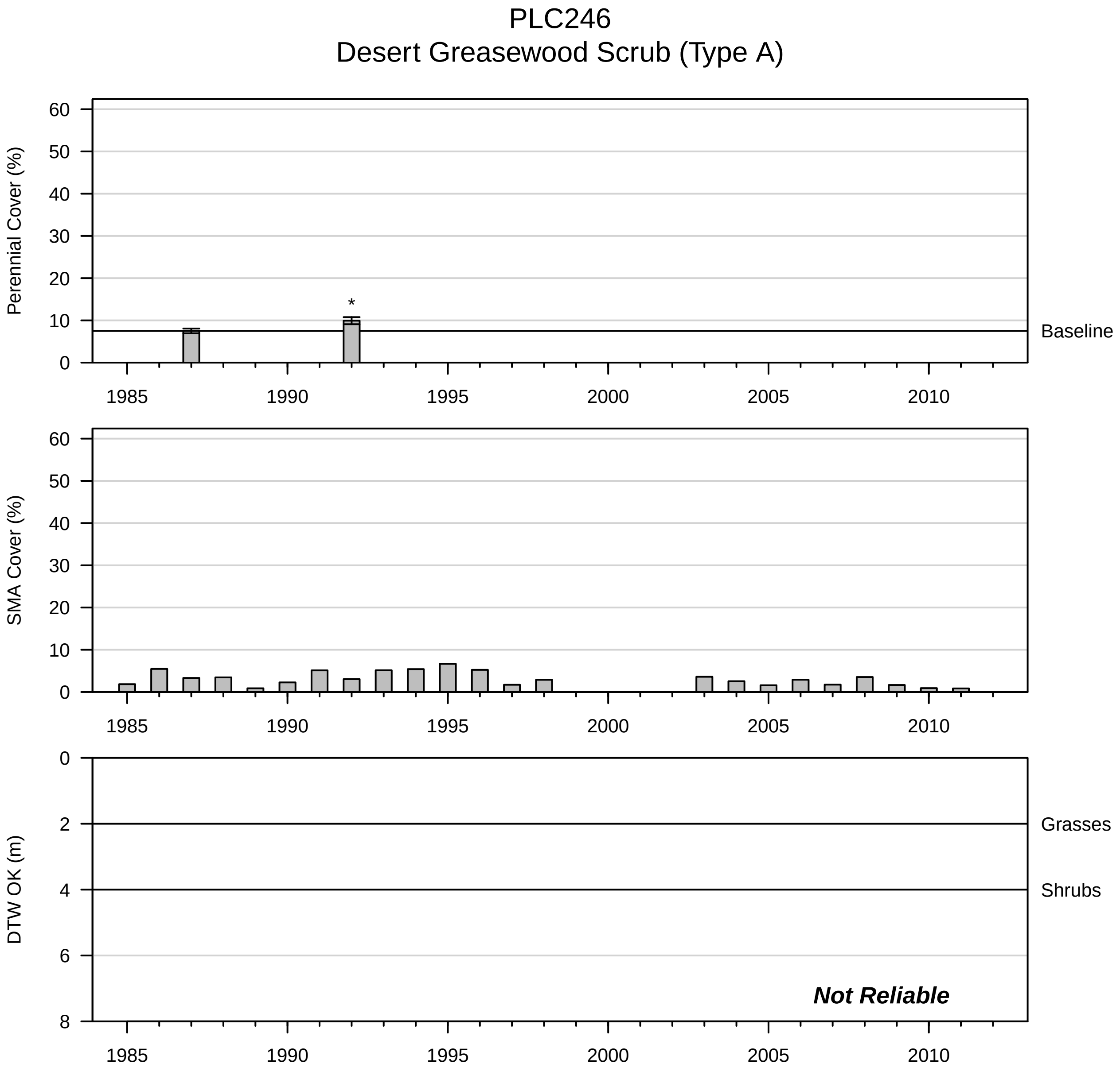

Figure 152: 1992 Control

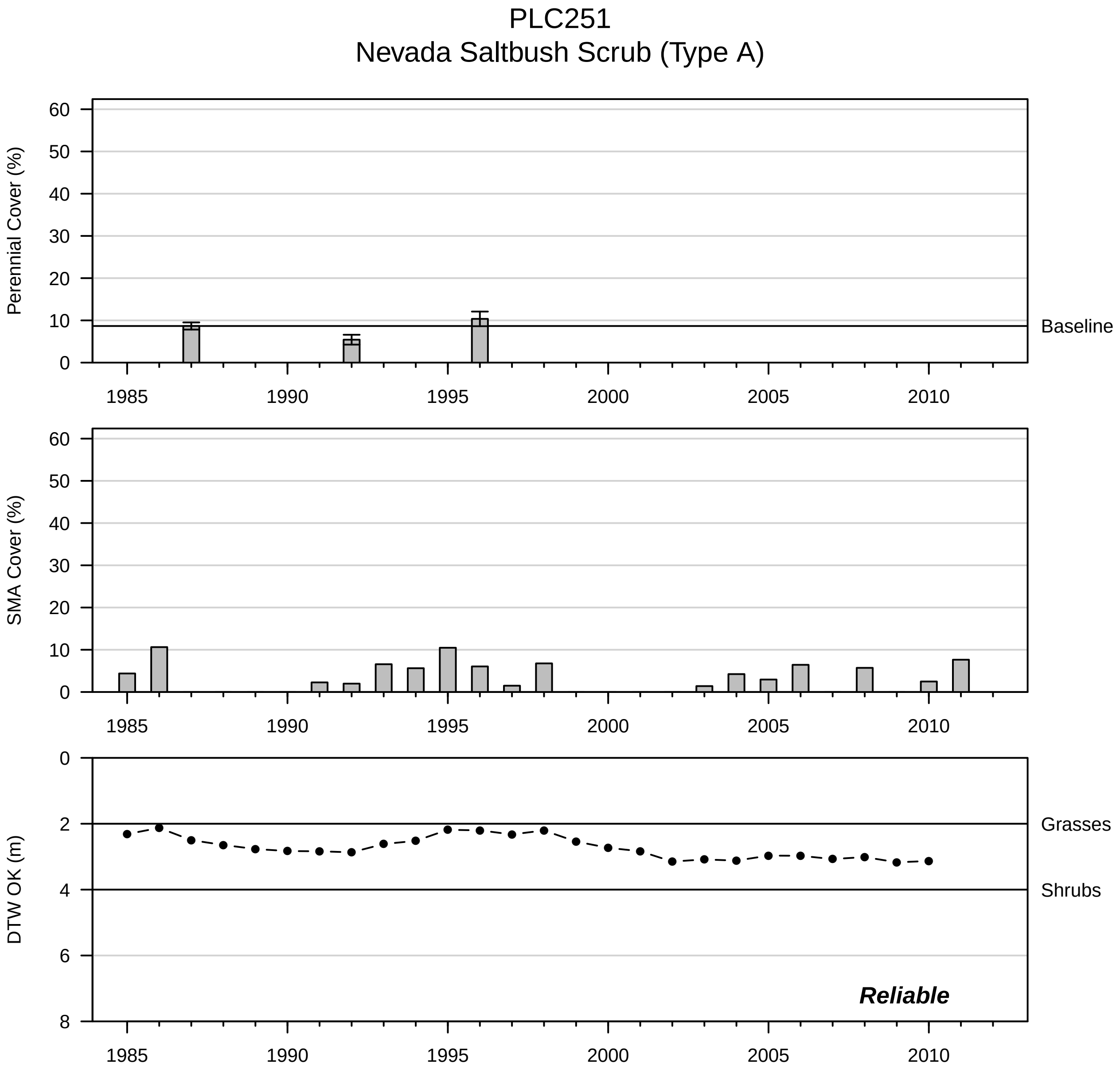

Figure 153: 1996 Control

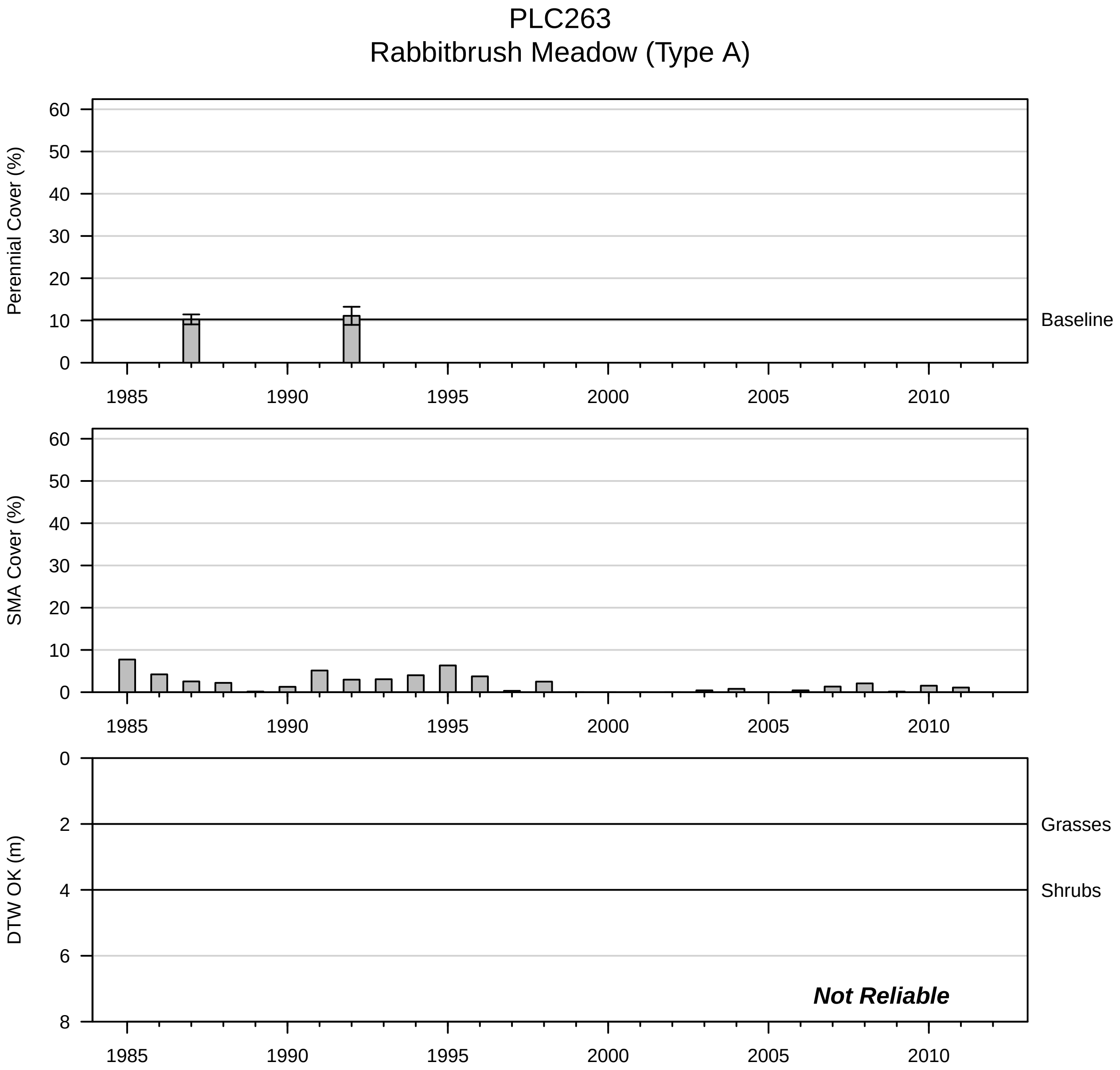

Figure 154: 1992 Control

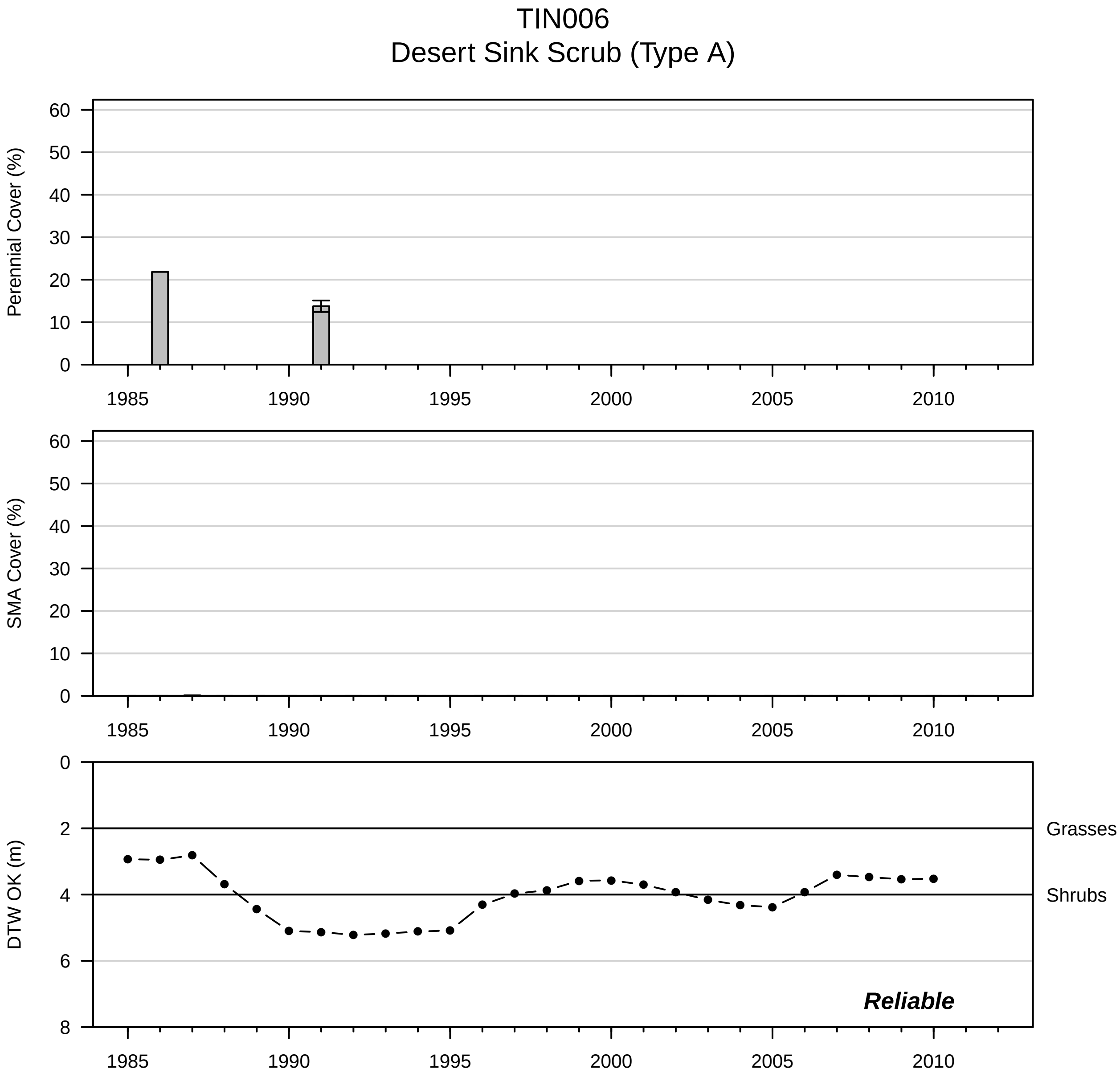

Figure 155: 1991 Wellfield

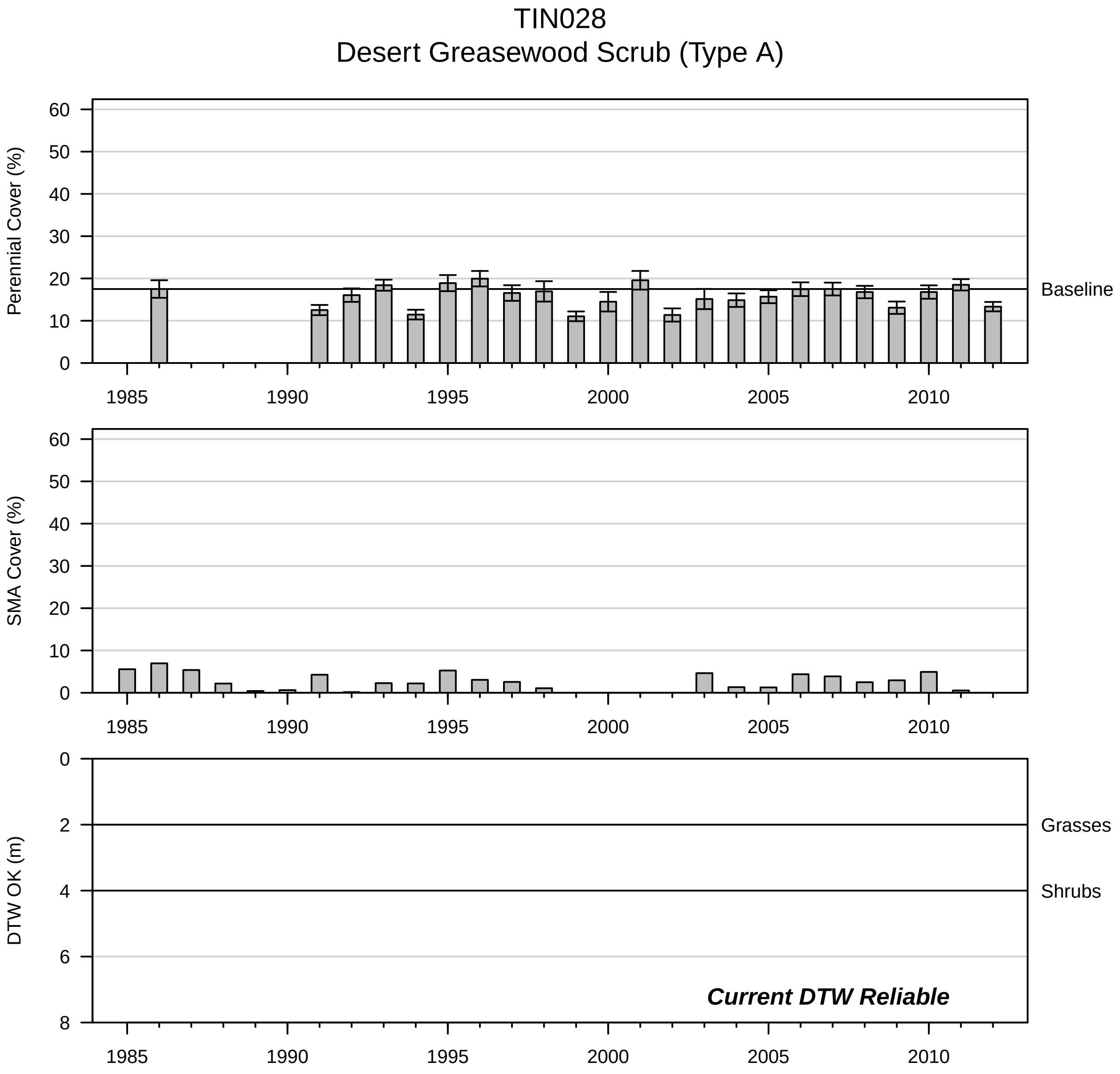

Figure 156: 2012 Wellfield

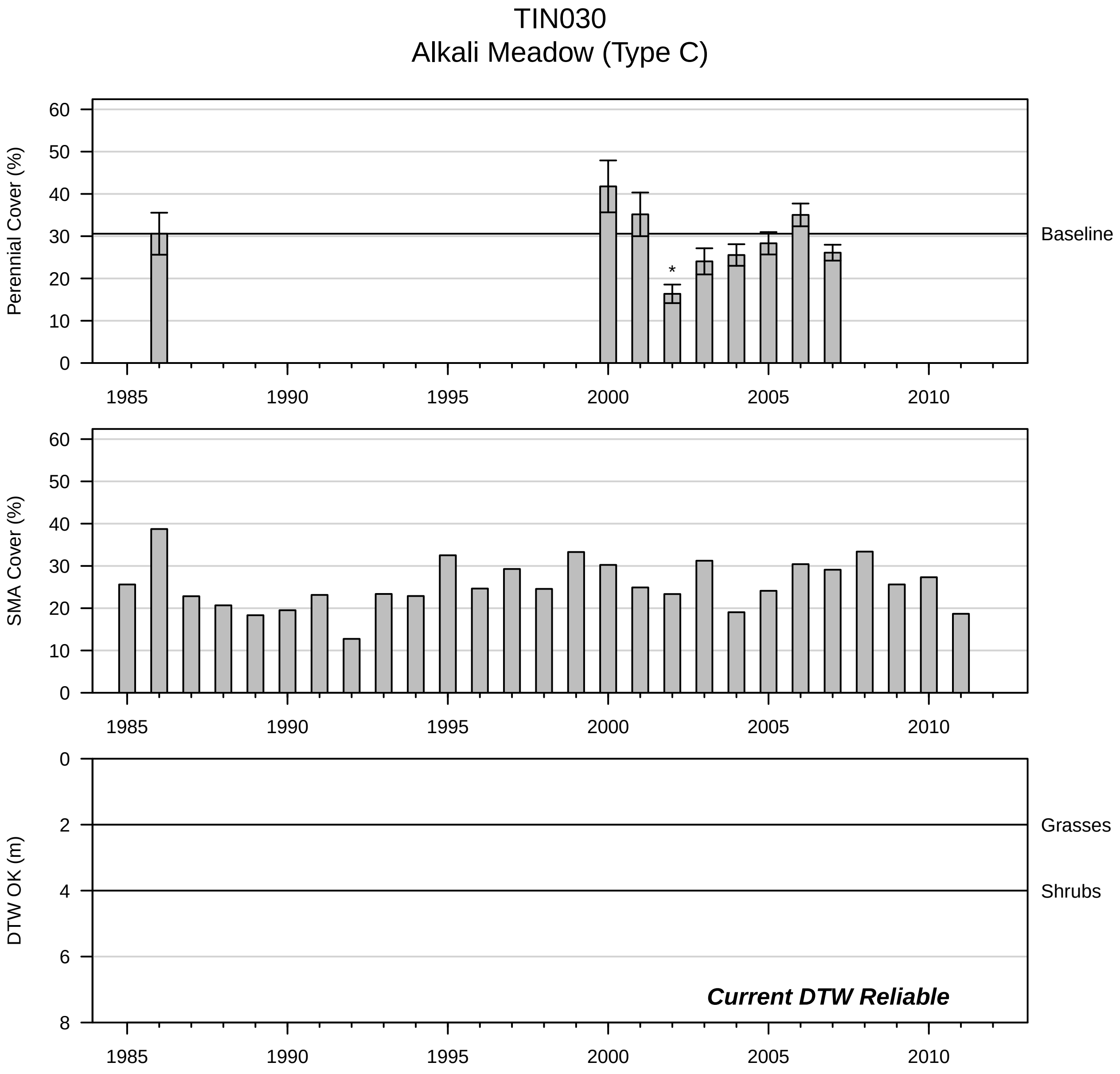

Figure 157: 2007 Wellfield

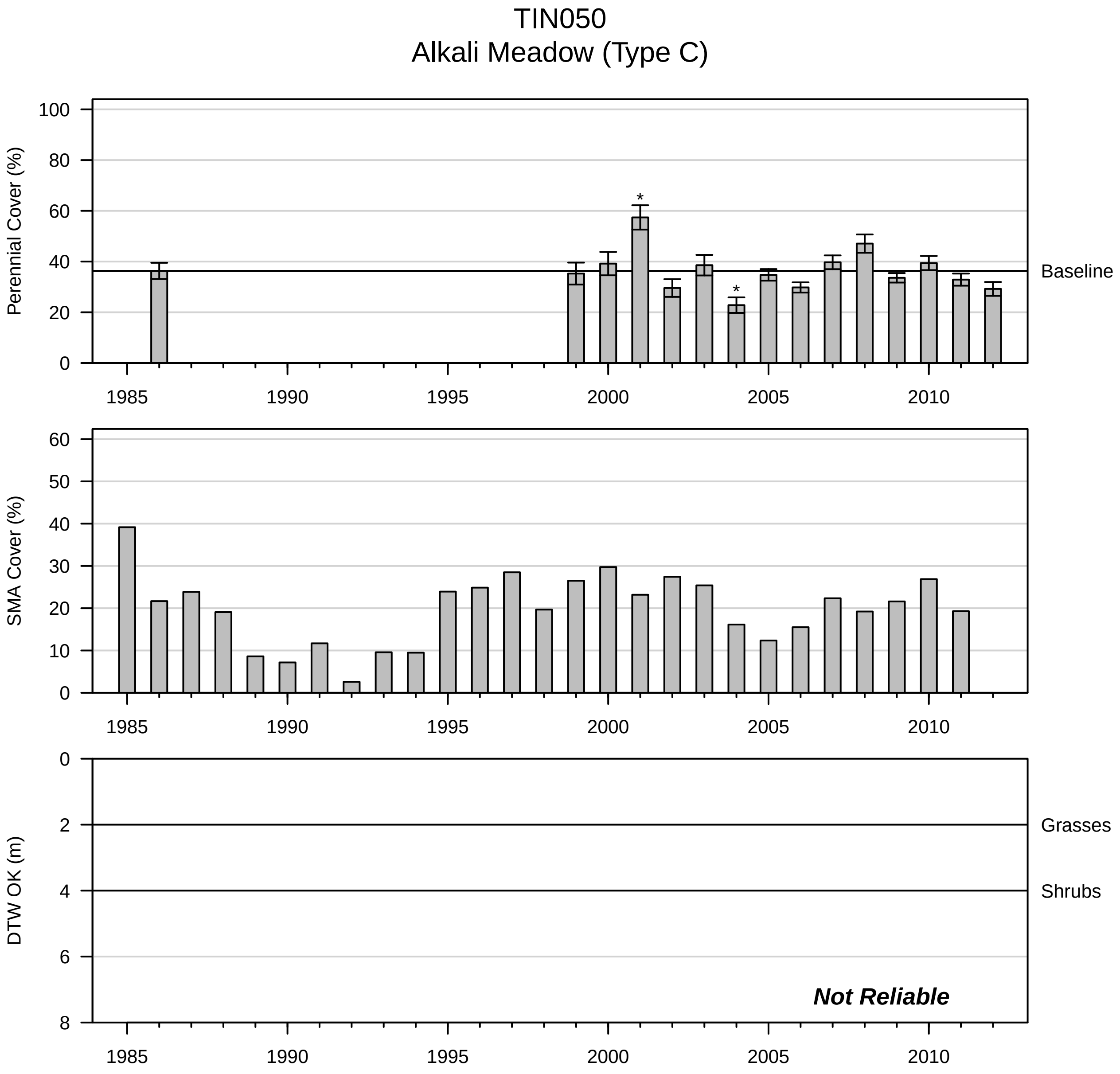

Figure 158: 2012 Wellfield

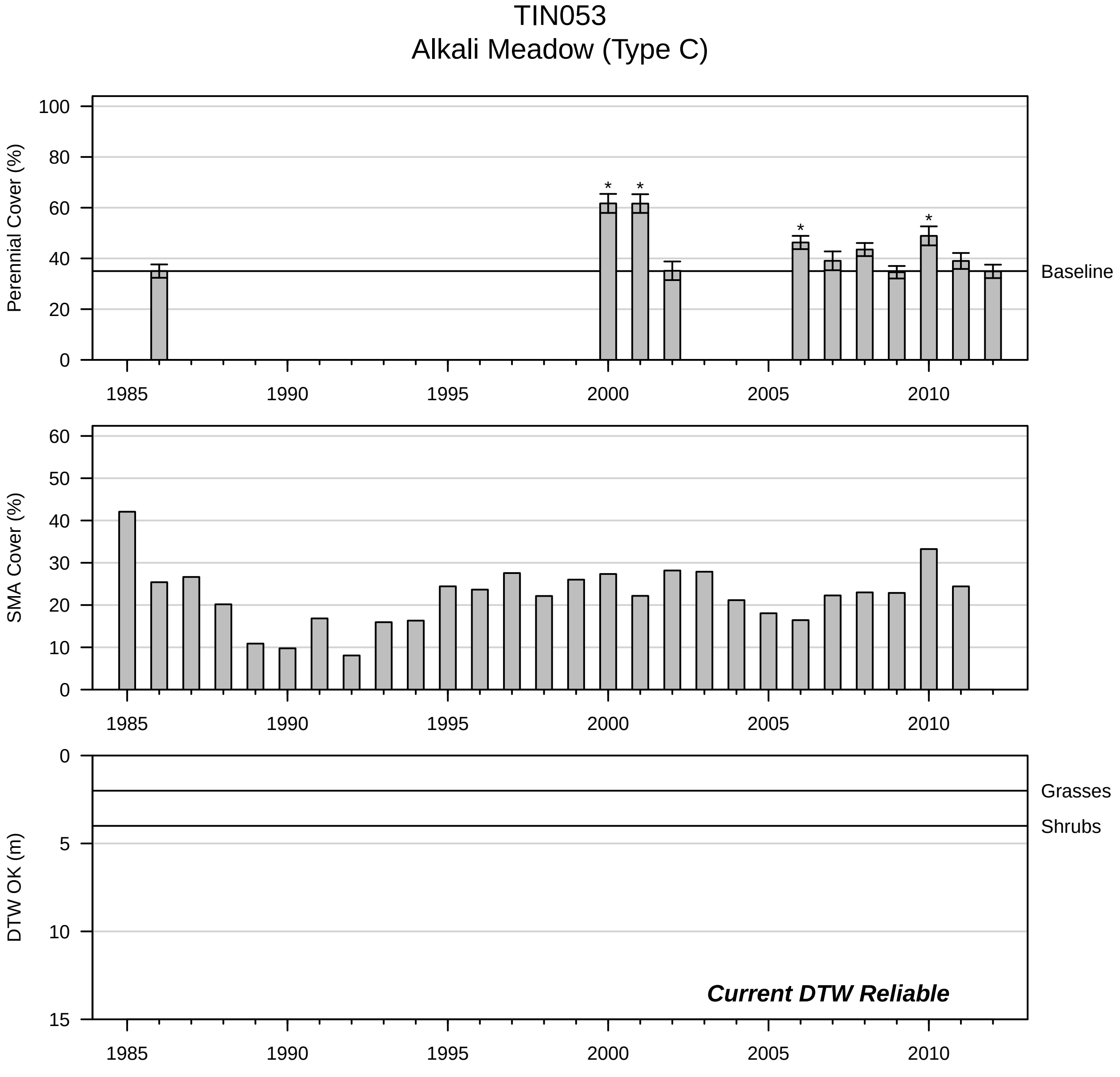

Figure 159: 2012 Wellfield

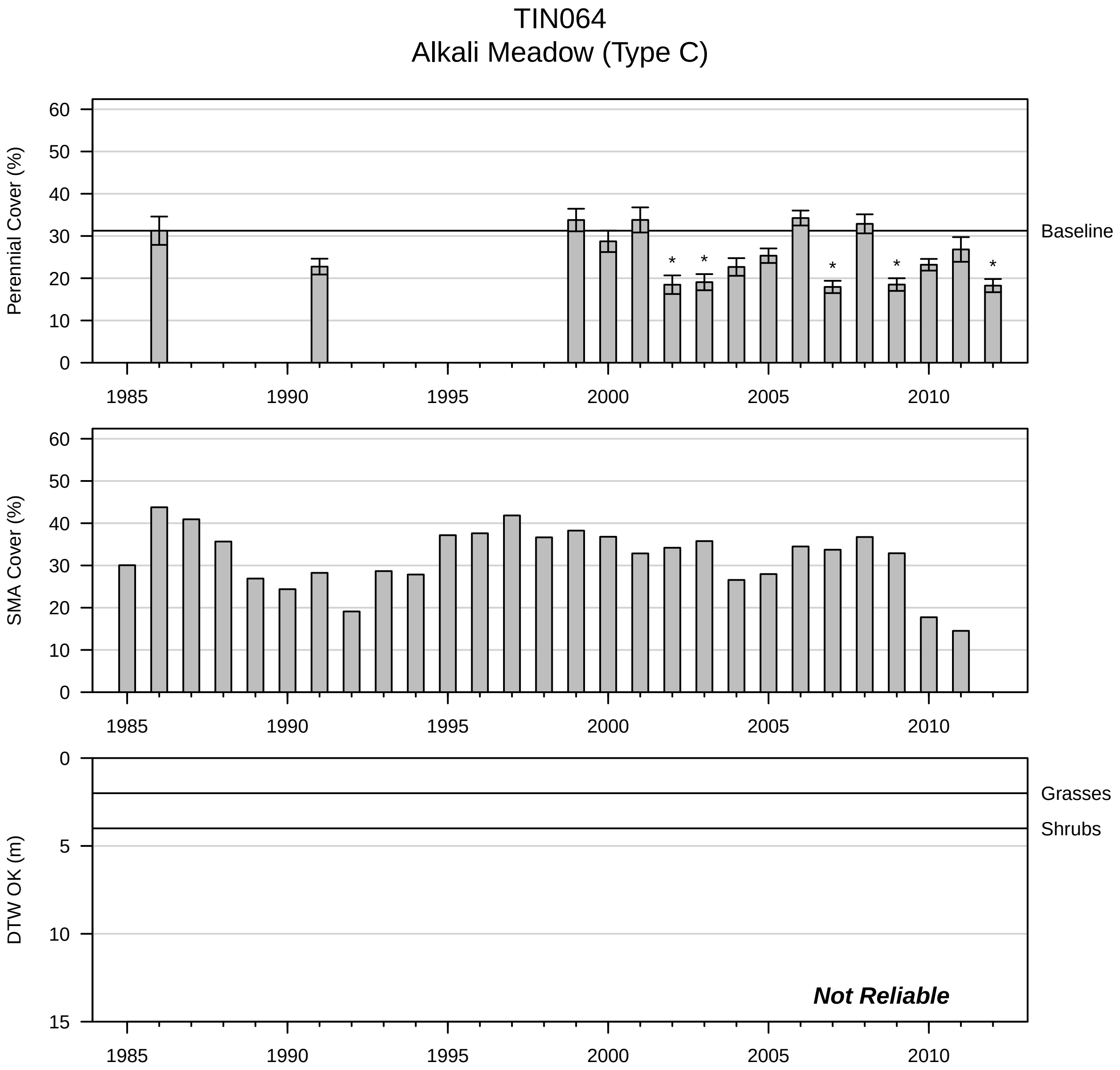

Figure 160: 2012 Wellfield

TIN068
Alkali Meadow (Type A)

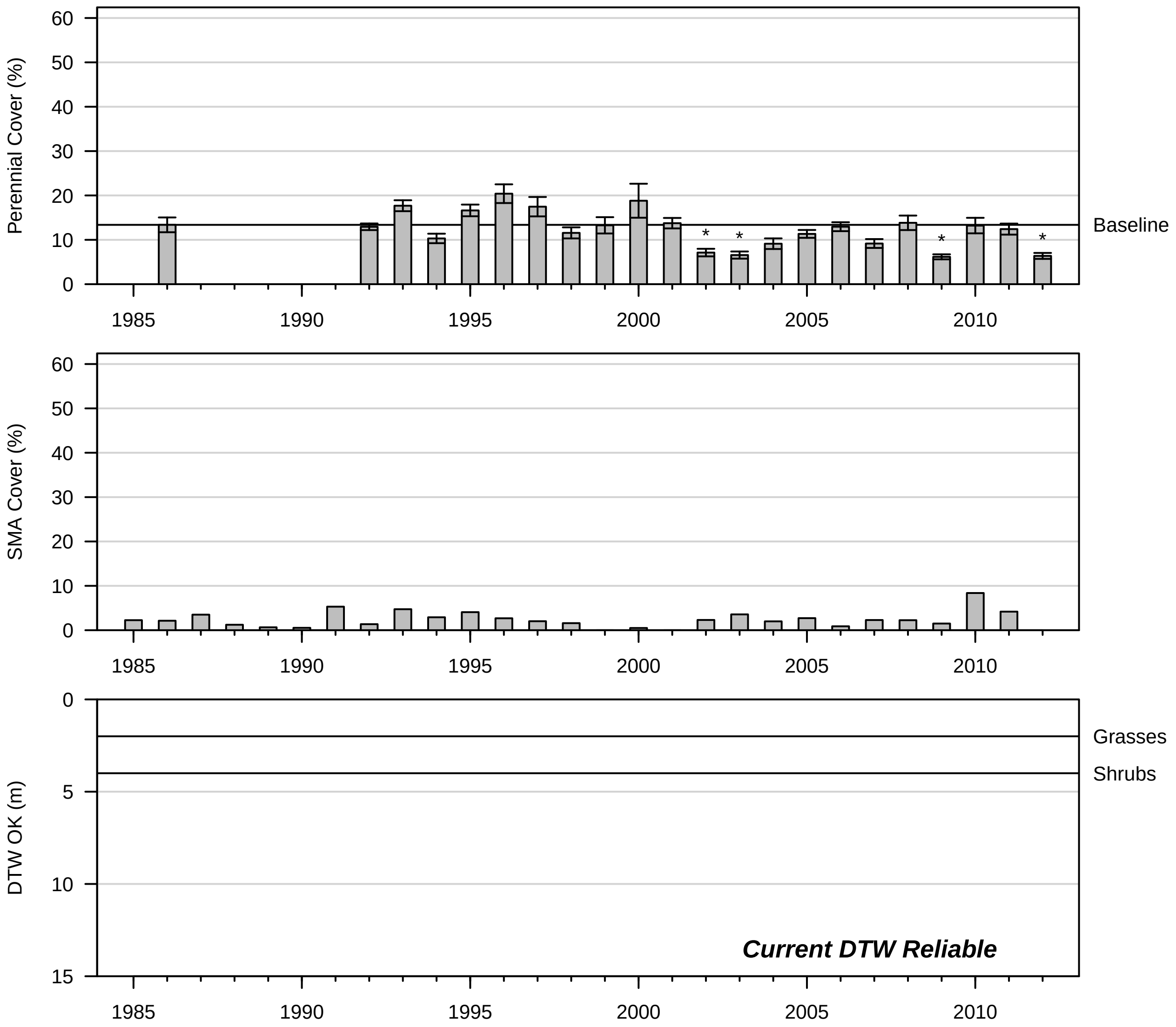

Figure 161: 2012 Wellfield

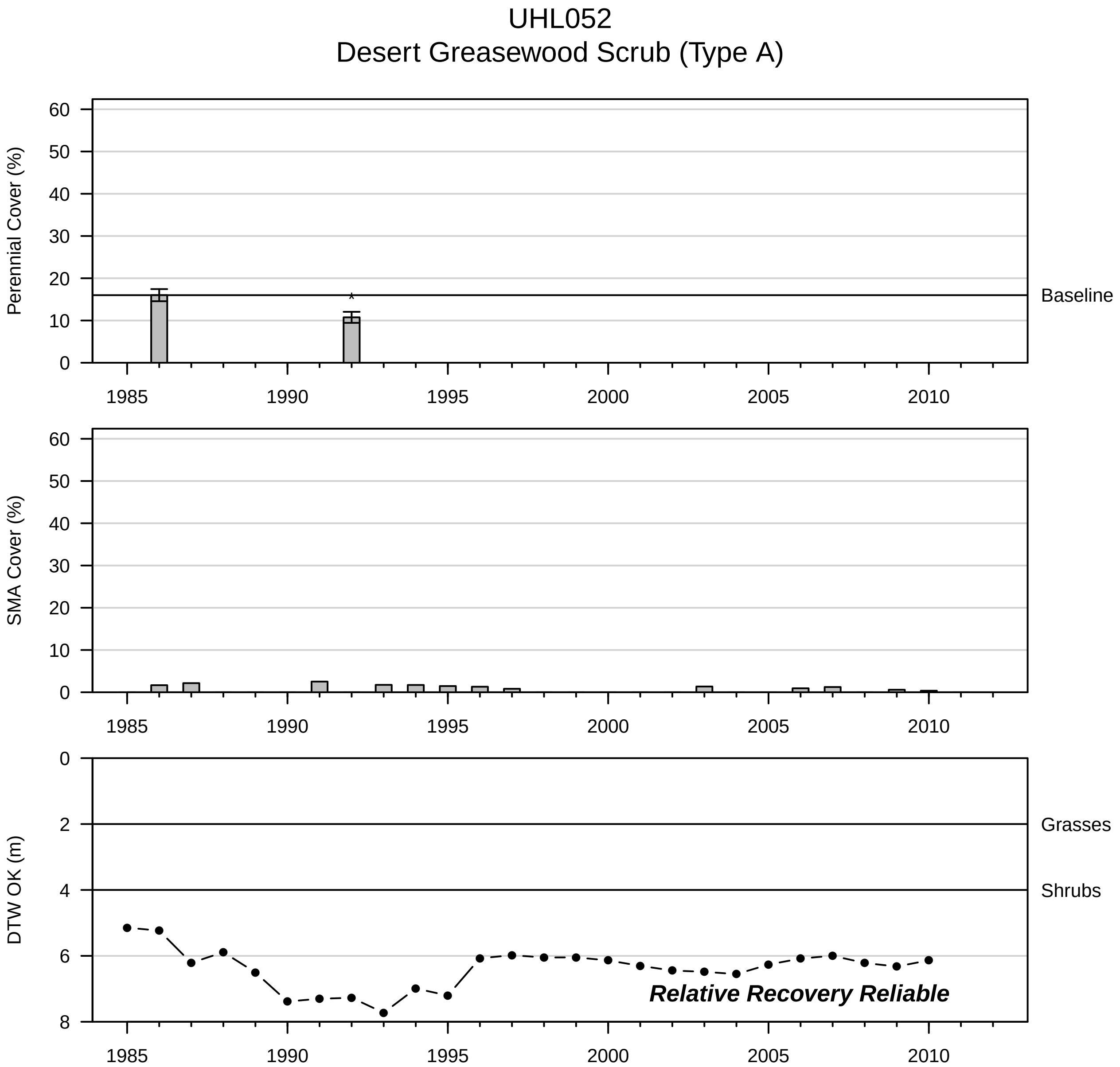

Figure 162: 1992 Wellfield

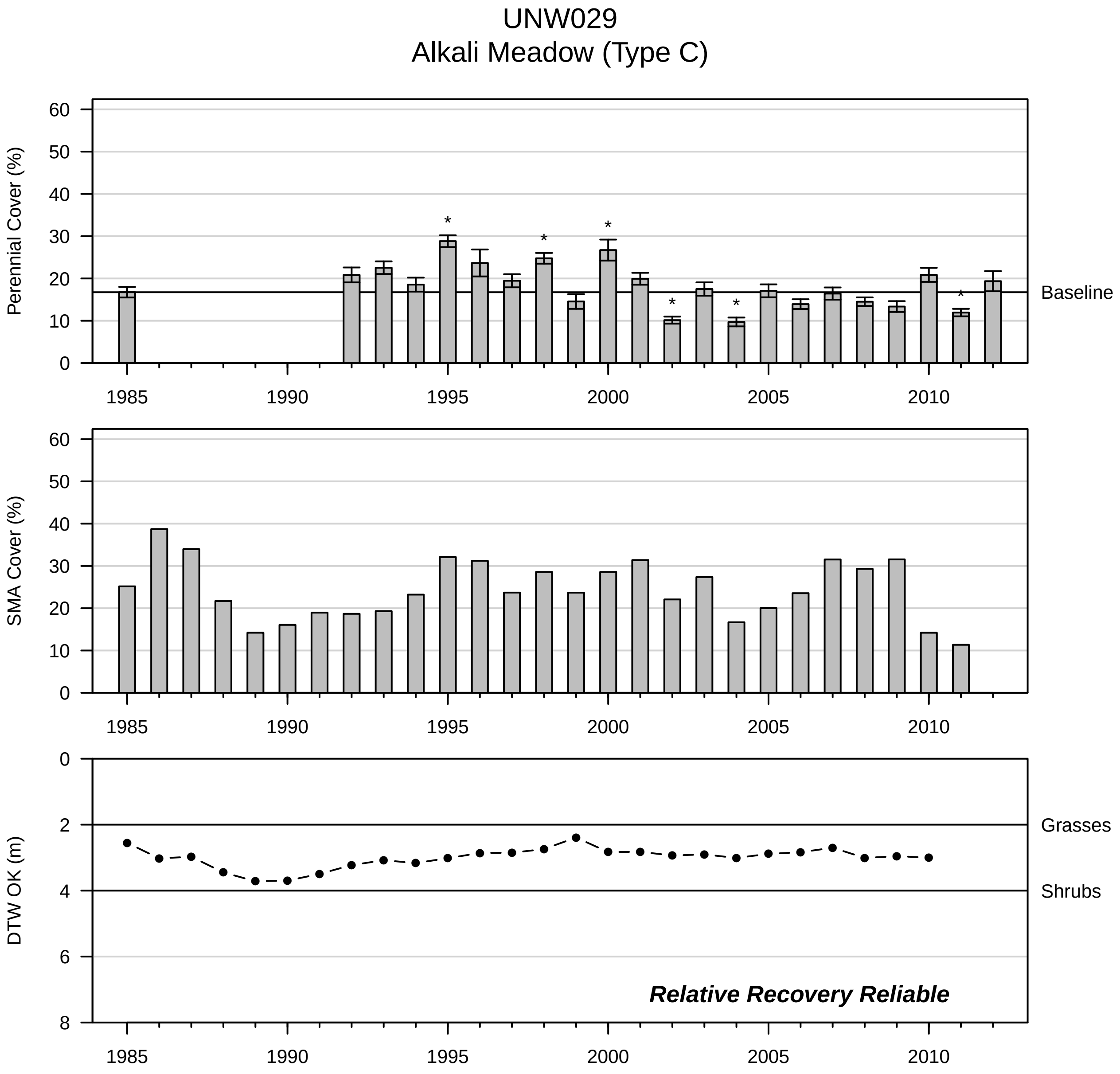

Figure 163: 2012 Control

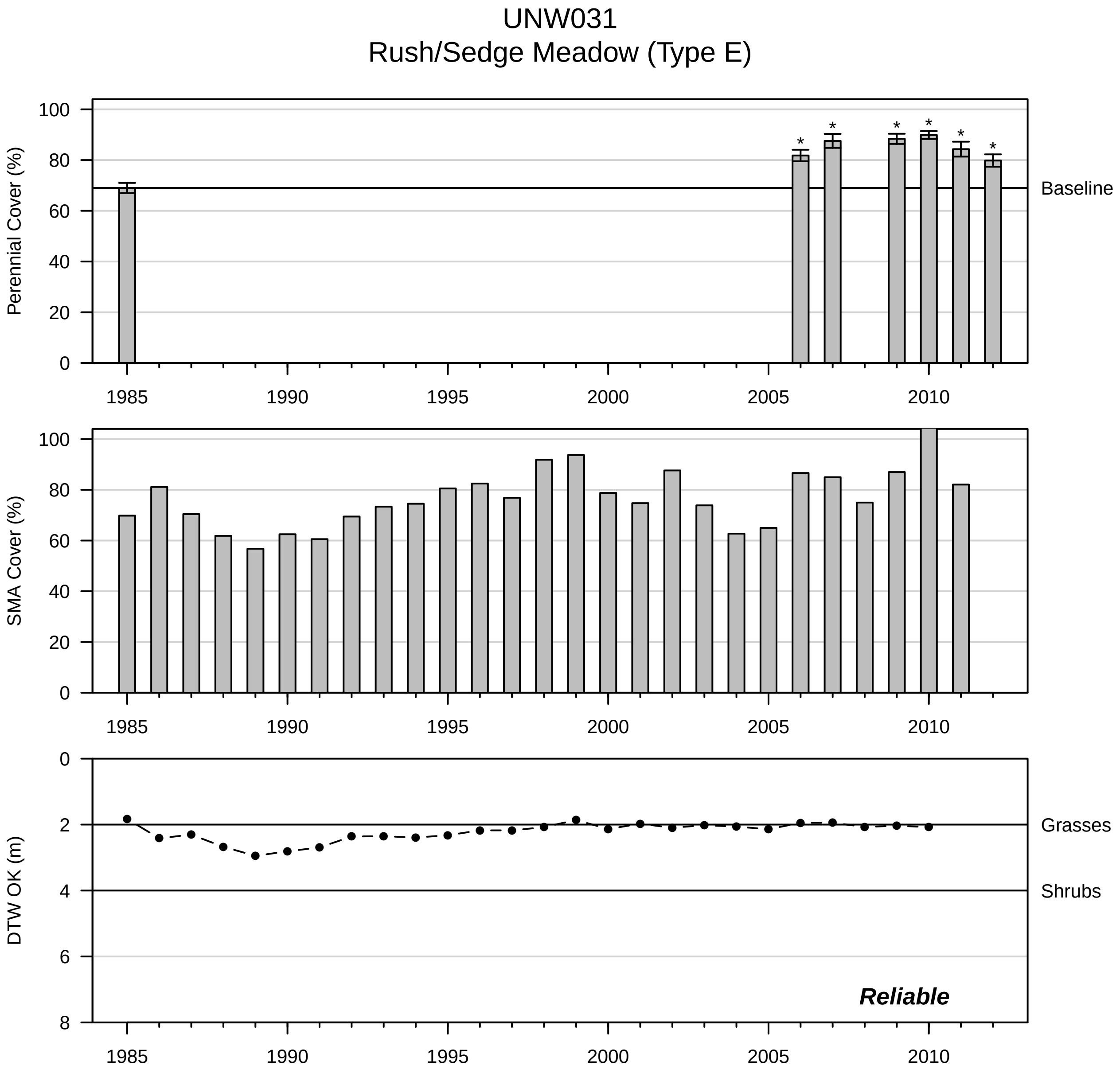

Figure 164: 2012 Control

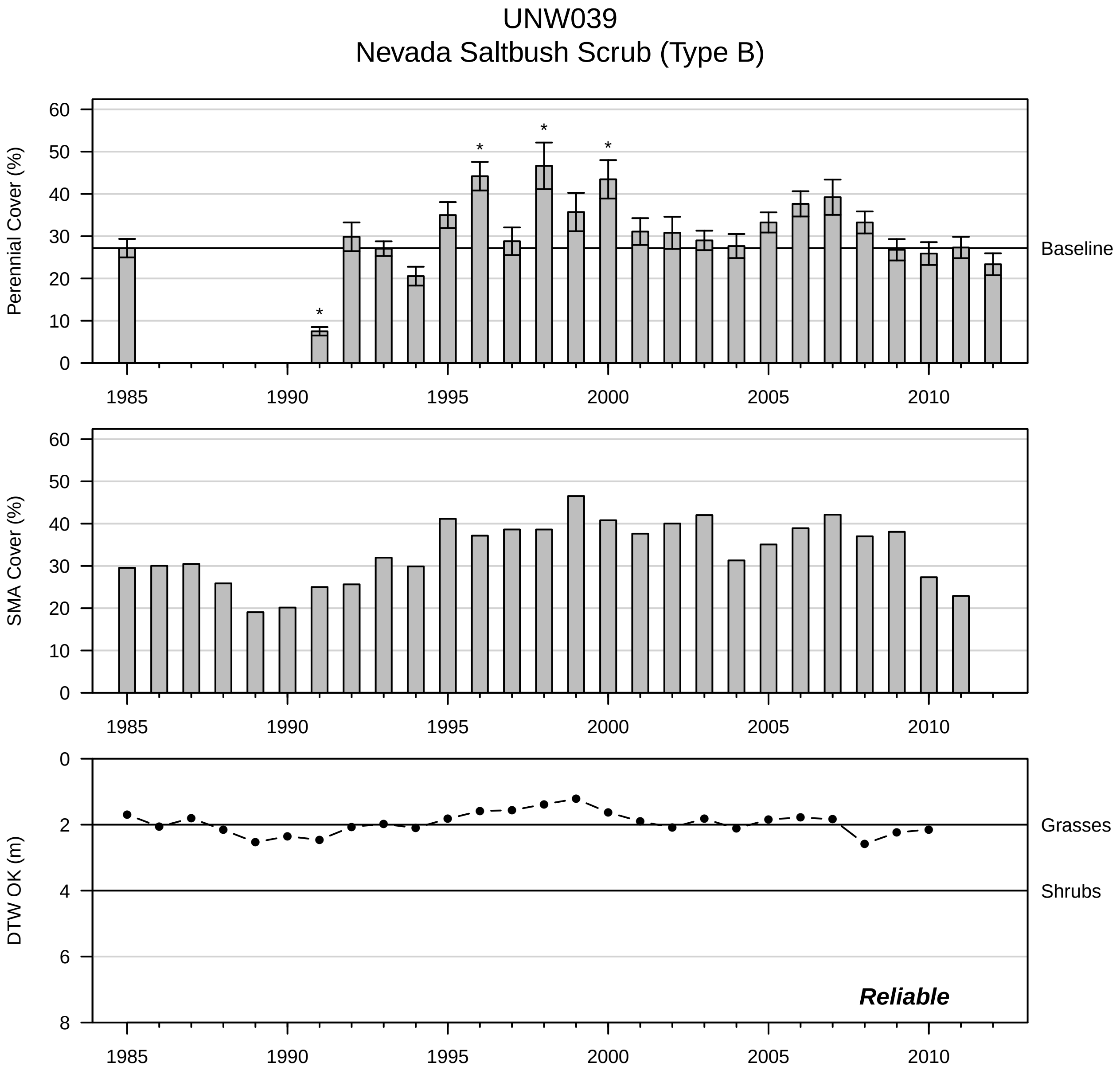

Figure 165: 2012 Control

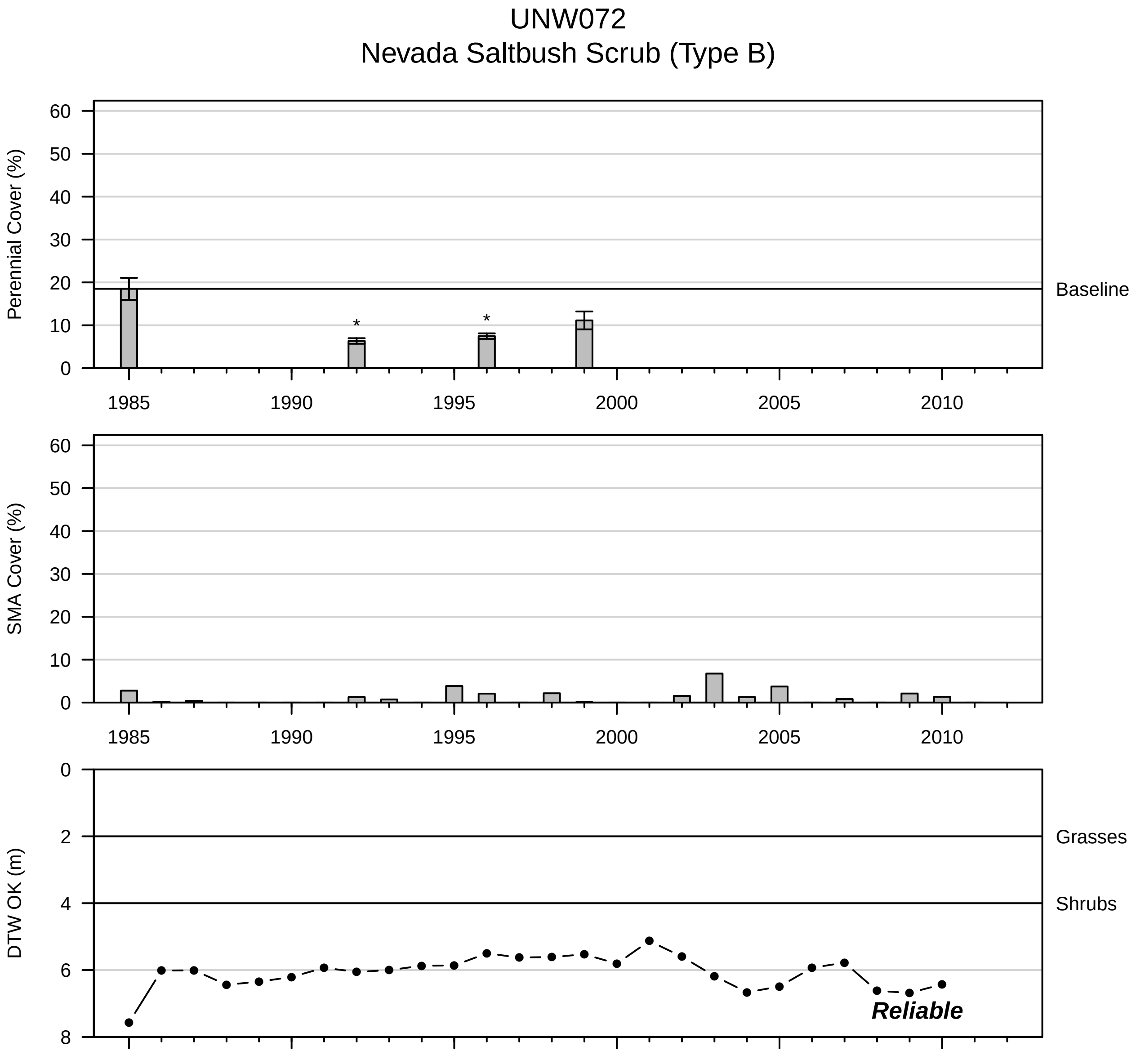

Figure 166: 1999 Control

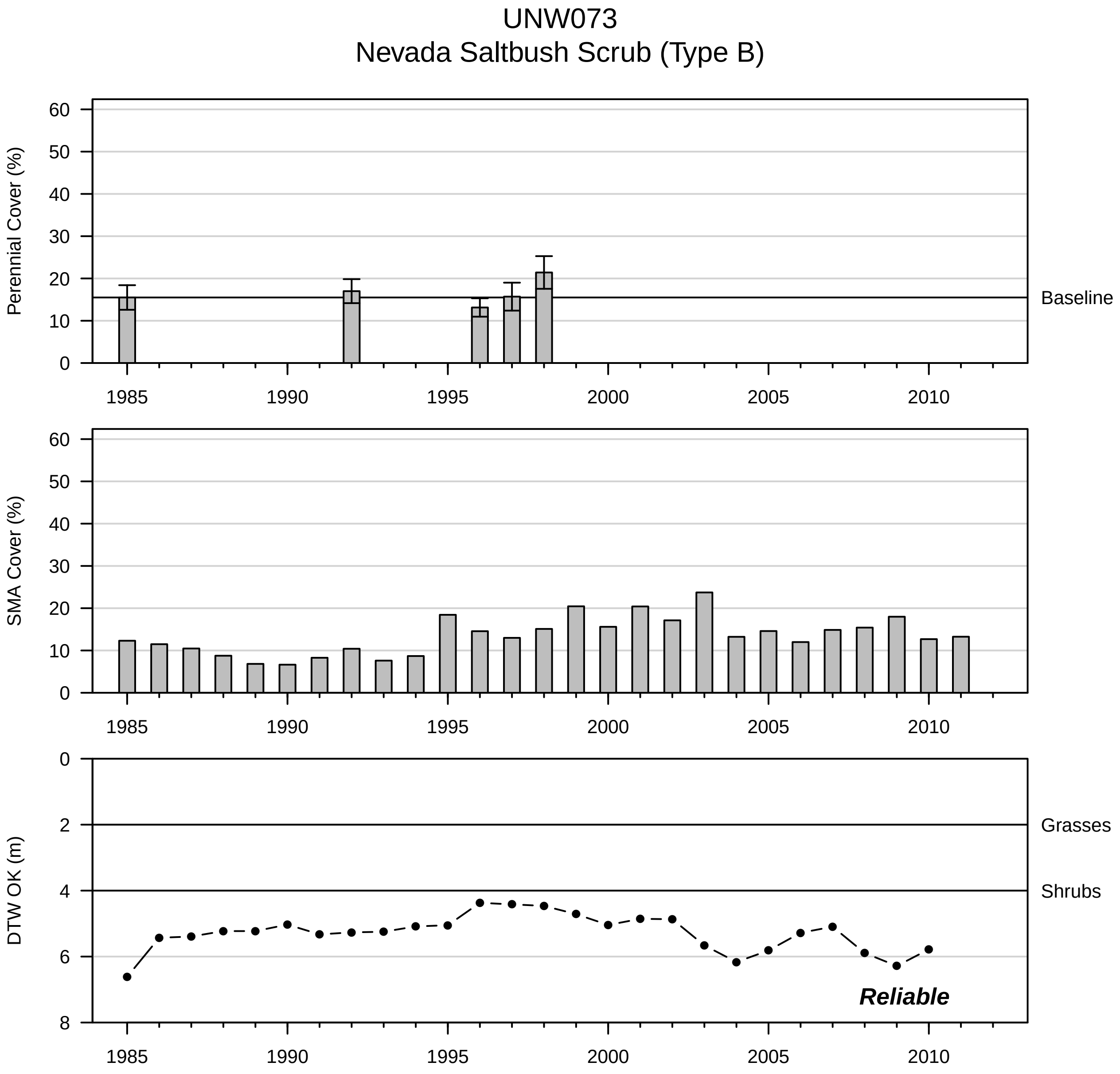

Figure 167: 1998 Control

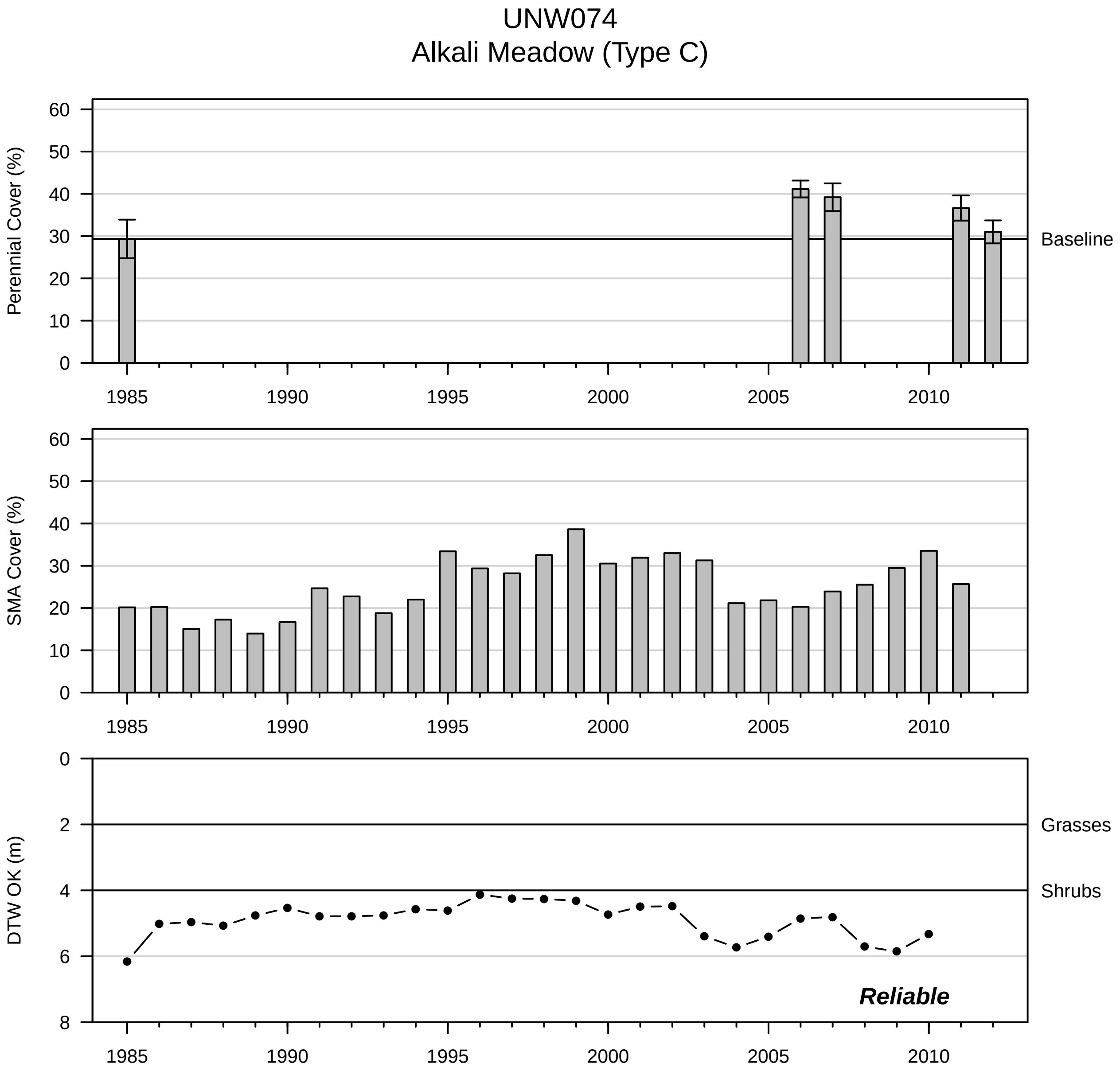

Figure 168: 2012 Control

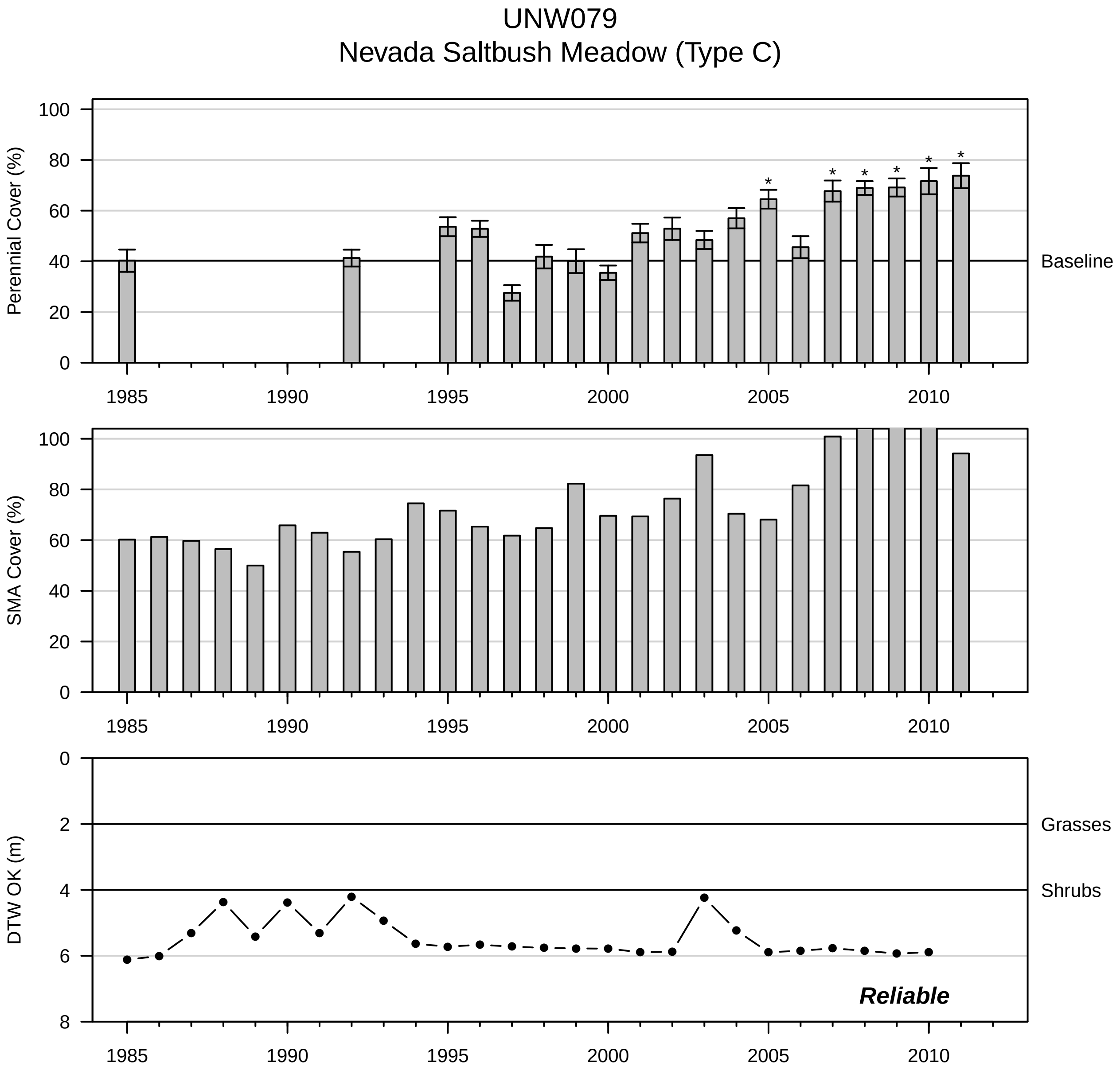

Figure 169: 2011 Control

W/C	Parcel ID	*n*	Perennial Shrub Cover						Perennial Herb Cover						Perennial Grass Cover					
			R ^{2}	***p***	**Slope**	**95% Confidence Interval**		**Slope direction**	***R*** ^{2}	***p***	**Slope**	**95% Confidence Interval**		**Slope direction**	***R*** ^{2}	***p***	**Slope**	**95% Confidence Interval**		**Slope direction**
						Lower	**Upper**					**Lower**	**Upper**					**Lower**	**Upper**	
C	BGP031	22	0.02	0.55	-0.001	-0.004	0.002		0.04	0.35	-0.001	-0.002	0.001		0.04	0.39	0.002	-0.002	0.005	
C	BGP047	18	0.21	**0.05**	0.005	0.000	0.009		0.05	0.35	-0.001	-0.004	0.002		0.13	0.15	-0.003	-0.008	0.001	
C	BGP204	10	0.09	0.41	-0.004	-0.013	0.006		0.41	**0.05**	0.006	0.000	0.011	+	0.03	0.65	-0.002	-0.012	0.008	
C	BGP205	11	0.18	0.20	0.009	-0.006	0.024		0.01	0.74	0.000	-0.002	0.002		0.18	0.19	-0.009	-0.024	0.006	
C	BIS055	14	0.13	0.21	0.004	-0.003	0.011		0.53	**0.00**	0.006	0.003	0.010	+	0.46	**0.01**	-0.011	-0.018	-0.003	-
C	BLK115	22	0.04	0.39	-0.002	-0.007	0.003		0.00	0.79	0.000	-0.002	0.002		0.06	0.28	0.002	-0.002	0.006	
C	FSL187	22	0.12	0.11	0.001	0.000	0.002		0.13	0.10	0.001	0.000	0.003		0.22	**0.03**	-0.002	-0.004	0.000	-
C	IND064	14	0.49	**0.01**	0.018	0.007	0.030	+	0.01	0.76	0.000	-0.001	0.002		0.46	**0.01**	-0.019	-0.031	-0.006	-
C	IND067	16	0.16	0.12	0.010	-0.003	0.023		0.04	0.49	0.001	-0.002	0.004		0.21	0.07	-0.011	-0.023	0.001	
C	IND096	23	0.27	**0.01**	-0.007	-0.012	-0.002	-	0.00	0.86	0.000	-0.002	0.003		0.33	**0.00**	0.007	0.002	0.011	+
C	IND119	19	0.47	**0.00**	0.009	0.004	0.014	+	0.09	0.21	0.000	0.000	0.001		0.49	**0.00**	-0.009	-0.014	-0.005	-
C	IND122	12	0.02	0.63	-0.001	-0.008	0.005		0.06	0.45	0.002	-0.003	0.006		0.00	0.90	0.000	-0.004	0.004	
C	IND163	23	0.42	**0.00**	0.009	0.004	0.014	+	0.25	**0.02**	-0.002	-0.003	0.000	-	0.29	**0.01**	-0.007	-0.012	-0.002	-
C	LNP018	22	0.12	0.11	0.005	-0.001	0.011		0.06	0.28	0.001	-0.001	0.002		0.14	0.09	-0.006	-0.012	0.001	
C	LNP019	16	0.27	**0.04**	-0.007	-0.014	0.000	-	0.14	0.15	-0.001	-0.003	0.001		0.36	**0.01**	0.008	0.002	0.014	+
C	LNP050	19	0.78	**0.00**	0.018	0.013	0.023	+	0.01	0.73	0.000	-0.002	0.003		0.81	**0.00**	-0.018	-0.023	-0.014	-
C	MAN014	17	0.00	0.96	0.000	-0.008	0.007		NA	NA	0.000	0.000	0.000		0.00	0.96	0.000	-0.007	0.008	
C	MAN060	22	0.16	0.06	0.002	0.000	0.003		0.00	0.97	0.000	-0.007	0.007		0.01	0.59	-0.002	-0.009	0.005	
C	PLC024	22	0.29	**0.01**	0.006	0.002	0.011	+	0.01	0.68	0.000	-0.001	0.002		0.36	**0.00**	-0.006	-0.010	-0.002	-
C	PLC056	11	0.24	0.12	0.005	-0.002	0.012		0.04	0.54	0.000	-0.001	0.002		0.24	0.13	-0.006	-0.013	0.002	
C	PLC059	10	0.03	0.62	-0.001	-0.006	0.004		0.23	0.16	0.001	0.000	0.002		0.01	0.84	0.000	-0.004	0.005	
C	PLC072	20	0.04	0.40	0.001	-0.001	0.003		0.12	0.13	0.000	0.000	0.000		0.04	0.38	-0.001	-0.003	0.001	
C	PLC092	14	0.45	**0.01**	0.005	0.001	0.008	+	0.04	0.50	0.000	0.000	0.000		0.46	**0.01**	-0.005	-0.008	-0.002	-
C	PLC097	20	0.00	0.78	0.001	-0.007	0.009		0.03	0.48	-0.001	-0.002	0.001		0.00	0.87	-0.001	-0.008	0.007	
C	PLC106	22	0.31	**0.01**	0.010	0.003	0.017	+	0.02	0.58	0.001	-0.001	0.002		0.34	**0.00**	-0.010	-0.017	-0.004	-
C	PLC121	21	0.43	**0.00**	0.004	0.002	0.007	+	0.12	0.12	-0.001	-0.003	0.000		0.20	**0.04**	-0.003	-0.006	0.000	-
C	PLC136	19	0.40	**0.00**	0.010	0.004	0.017	+	0.01	0.64	0.000	-0.001	0.001		0.43	**0.00**	-0.010	-0.016	-0.004	-
C	PLC137	22	0.01	0.64	-0.001	-0.005	0.003		0.01	0.67	0.000	-0.002	0.001		0.02	0.50	0.001	-0.002	0.005	
C	PLC144	10	0.23	0.16	-0.002	-0.006	0.001		0.15	0.27	0.001	-0.001	0.003		0.06	0.50	0.001	-0.003	0.006	
C	PLC223	23	0.32	**0.01**	0.006	0.002	0.009	+	0.36	**0.00**	0.001	0.000	0.002	+	0.38	**0.00**	-0.007	-0.011	-0.003	-
C	UNW029	22	0.33	**0.01**	0.008	0.003	0.013	+	0.04	0.36	0.000	0.000	0.000		0.33	**0.01**	-0.008	-0.013	-0.003	-
C	UNW039	23	0.43	**0.00**	-0.010	-0.015	-0.005	-	0.07	0.23	0.001	0.000	0.001		0.42	**0.00**	0.009	0.004	0.015	+
C	UNW079	19	0.29	**0.02**	-0.012	-0.021	-0.002	-	0.09	0.21	-0.002	-0.004	0.001		0.42	**0.00**	0.013	0.005	0.021	+
W	BGP086	18	0.49	**0.00**	-0.015	-0.024	-0.007	-	0.27	**0.03**	0.001	0.000	0.002	+	0.46	**0.00**	0.014	0.006	0.022	+
W	BGP154	22	0.33	**0.01**	0.006	0.002	0.010	+	0.02	0.54	0.000	-0.002	0.001		0.36	**0.00**	-0.005	-0.009	-0.002	-
W	BGP157	16	0.40	**0.01**	-0.009	-0.016	-0.003	-	0.32	**0.02**	0.001	0.000	0.002	+	0.37	**0.01**	0.008	0.002	0.015	+
W	BLK009	23	0.02	0.55	0.002	-0.004	0.007		0.36	**0.00**	0.000	0.000	0.001	+	0.03	0.45	-0.002	-0.007	0.003	
W	BLK016	15	0.08	0.30	0.003	-0.003	0.010		0.04	0.45	0.001	-0.002	0.003		0.16	0.13	-0.004	-0.010	0.002	
W	BLK021	16	0.31	**0.03**	0.008	0.001	0.015	+	0.01	0.77	0.000	-0.001	0.001		0.32	**0.02**	-0.008	-0.015	-0.001	-
W	BLK024	23	0.15	0.06	0.004	0.000	0.009		0.01	0.74	0.000	-0.001	0.001		0.15	0.06	-0.005	-0.009	0.000	
W	BLK033	12	0.03	0.62	0.003	-0.010	0.015		0.00	0.91	0.000	-0.006	0.006		0.03	0.61	-0.003	-0.014	0.008	
W	BLK039	22	0.16	0.06	0.005	0.000	0.011		0.57	**0.00**	0.003	0.002	0.004	+	0.30	**0.01**	-0.008	-0.014	-0.002	-
W	BLK044	22	0.61	**0.00**	0.017	0.011	0.024	+	0.01	0.63	0.001	-0.004	0.007		0.75	**0.00**	-0.019	-0.024	-0.014	-
W	BLK069	22	0.00	0.87	0.000	-0.005	0.006		0.14	0.08	0.000	0.000	0.001		0.01	0.74	-0.001	-0.006	0.004	
W	BLK074	21	0.06	0.30	-0.003	-0.008	0.003		0.05	0.33	0.000	0.000	0.001		0.05	0.34	0.003	-0.003	0.008	
W	BLK075	21	0.64	**0.00**	0.020	0.013	0.027	+	0.21	**0.04**	0.004	0.000	0.007	+	0.78	**0.00**	-0.023	-0.029	-0.017	-
W	BLK077	11	0.28	0.09	-0.005	-0.011	0.001		0.01	0.77	0.000	0.000	0.000		0.28	0.09	0.005	-0.001	0.011	
W	BLK094	21	0.65	**0.00**	0.013	0.008	0.017	+	0.00	0.86	0.000	-0.002	0.002		0.63	**0.00**	-0.013	-0.018	-0.008	-
W	BLK099	23	0.00	0.80	0.000	-0.003	0.002		0.37	**0.00**	0.002	0.001	0.004	+	0.10	0.14	-0.002	-0.005	0.001	
W	BLK142	20	0.43	**0.00**	0.008	0.004	0.013	+	0.03	0.44	0.000	0.000	0.000		0.43	**0.00**	-0.008	-0.013	-0.004	-
W	FSL065	19	0.81	**0.00**	0.018	0.014	0.023	+	0.06	0.29	-0.001	-0.002	0.001		0.77	**0.00**	-0.017	-0.022	-0.013	-
W	FSL116	11	0.71	**0.00**	0.010	0.005	0.015	+	0.16	0.22	0.002	-0.002	0.006		0.63	**0.00**	-0.012	-0.020	-0.005	-
W	FSL123	21	0.13	0.11	0.003	-0.001	0.008		0.00	0.83	0.001	-0.004	0.005		0.10	0.16	-0.004	-0.009	0.002	
W	FSP004	17	0.03	0.54	-0.002	-0.009	0.005		0.12	0.17	0.000	0.000	0.000		0.02	0.56	0.002	-0.005	0.009	
W	FSP006	22	0.42	**0.00**	0.013	0.006	0.020	+	0.01	0.73	0.000	0.000	0.000		0.42	**0.00**	-0.013	-0.020	-0.006	-
W	IND011	22	0.55	**0.00**	0.010	0.006	0.014	+	0.13	0.10	-0.003	-0.007	0.001		0.17	0.06	-0.007	-0.013	0.000	
W	IND019	16	0.07	0.33	-0.005	-0.016	0.006		0.34	**0.02**	-0.006	-0.011	-0.001	-	0.35	**0.02**	0.011	0.002	0.020	+
W	IND029	13	0.74	**0.00**	0.019	0.012	0.026	+	0.01	0.76	0.000	-0.002	0.002		0.69	**0.00**	-0.019	-0.028	-0.011	-
W	IND035	22	0.81	**0.00**	0.011	0.009	0.014	+	0.01	0.74	0.000	-0.002	0.002		0.73	**0.00**	-0.012	-0.015	-0.008	-
W	IND106	13	0.00	0.85	0.000	-0.003	0.004		0.02	0.67	0.000	-0.002	0.001		0.00	0.99	0.000	-0.002	0.002	
W	IND111	23	0.00	0.78	0.001	-0.005	0.006		0.01	0.74	0.000	-0.002	0.003		0.01	0.70	-0.001	-0.007	0.004	
W	IND132	21	0.37	**0.00**	0.005	0.002	0.007	+	0.15	0.09	-0.001	-0.003	0.000		0.38	**0.00**	-0.003	-0.005	-0.001	-
W	IND139	23	0.08	0.19	0.003	-0.002	0.008		0.01	0.71	0.000	-0.001	0.000		0.08	0.19	-0.003	-0.008	0.002	
W	IND231	14	0.10	0.27	0.001	-0.001	0.002		0.04	0.50	0.000	-0.002	0.001		0.14	0.19	0.000	-0.001	0.000	
W	LAW030	11	0.38	**0.04**	-0.011	-0.022	-0.001	-	0.05	0.52	0.001	-0.003	0.005		0.33	0.06	0.010	-0.001	0.021	
W	LAW062	12	0.24	0.10	0.007	-0.002	0.017		0.00	0.98	0.000	-0.006	0.006		0.39	**0.03**	-0.007	-0.014	-0.001	-
W	LAW063	14	0.00	0.83	-0.001	-0.013	0.011		0.00	0.90	0.000	-0.003	0.003		0.01	0.79	0.001	-0.010	0.012	
W	LAW078	16	0.05	0.41	-0.004	-0.013	0.006		0.00	0.88	0.000	-0.004	0.005		0.04	0.47	0.003	-0.006	0.013	
W	LAW085	21	0.05	0.31	0.004	-0.004	0.012		0.09	0.19	-0.001	-0.003	0.001		0.03	0.45	-0.003	-0.011	0.005	
W	LAW107	22	0.03	0.46	0.002	-0.003	0.007		0.06	0.27	-0.002	-0.006	0.002		0.00	0.92	0.000	-0.007	0.007	
W	LAW110	11	0.06	0.48	0.005	-0.010	0.019		0.62	**0.00**	-0.004	-0.007	-0.002	-	0.00	0.92	-0.001	-0.015	0.014	
W	LAW112	20	0.03	0.46	-0.003	-0.012	0.006		0.04	0.37	0.000	-0.001	0.000		0.04	0.42	0.003	-0.005	0.012	
W	LAW120	23	0.02	0.57	-0.002	-0.010	0.006		0.16	0.06	0.003	0.000	0.005		0.00	0.90	0.000	-0.008	0.007	
W	LAW122	22	0.08	0.20	0.001	0.000	0.001		0.11	0.12	0.003	-0.001	0.007		0.15	0.07	-0.003	-0.007	0.000	
W	LNP045	20	0.32	**0.01**	0.007	0.002	0.012	+	0.04	0.37	-0.002	-0.007	0.003		0.15	0.09	-0.005	-0.011	0.001	
W	MAN006	22	0.05	0.33	-0.003	-0.010	0.003		0.00	0.94	0.000	-0.001	0.000		0.04	0.34	0.003	-0.004	0.010	
W	MAN037	12	0.11	0.30	-0.003	-0.008	0.003		0.15	0.22	0.003	-0.002	0.007		0.00	0.99	0.000	-0.005	0.005	
W	TIN028	20	0.03	0.47	0.001	-0.003	0.005		0.07	0.25	0.000	-0.001	0.000		0.02	0.53	-0.001	-0.005	0.003	
W	TIN050	15	0.27	**0.05**	0.013	0.000	0.025	+	0.03	0.51	0.000	-0.001	0.001		0.29	**0.04**	-0.013	-0.025	-0.001	-
W	TIN053	11	0.35	0.06	0.008	0.000	0.017		0.00	0.96	0.000	-0.001	0.001		0.31	0.08	-0.008	-0.018	0.001	
W	TIN064	16	0.27	**0.04**	0.010	0.001	0.020	+	0.11	0.20	0.000	-0.001	0.000		0.26	**0.05**	-0.010	-0.020	0.000	-
W	TIN068	21	0.33	**0.01**	0.008	0.003	0.014	+	0.05	0.35	0.000	0.000	0.000		0.33	**0.01**	-0.008	-0.014	-0.003	-