

NEVADA IRRIGATION DISTRICT

INTEGRATED VEGETATION MANAGEMENT PROGRAM

PHASE 3 REPORT

BACKGROUND

Nevada Irrigation District (NID or District) is an independent special district located on the western slope of the Sierra Nevada mountain range. The District encompasses 287,000 acres with available water in wide areas of Nevada, Placer and Yuba counties and storage and distribution facilities in Sierra and Yuba counties. The District service area ranges from 138 feet to 6,600 feet in elevation and includes a variety of landscape cover types including conifer forest, oak woodland, grassland, foothill residential areas and lowland residential areas. NID is organized primarily to supply water for irrigation, municipal, domestic and industrial purposes.

In an effort to deliver a reliable low cost source of water to customers, the District's Integrated Vegetation Management (IVM) Program incorporates the use of biological, chemical, cultural, manual and mechanical treatments to control vegetation growth in and around District infrastructure. Unmanaged vegetation can choke off canals, reduce water storage capacity and impact water quality and public health. The District IVM Program is a critical element of canal and reservoir maintenance, supporting adequate water flow for human consumption, irrigation and fire suppression.

The District IVM Program aims to continue implementation of adaptive management techniques that are environmentally sound, effective, efficient, fiscally prudent and compliant with regulatory requirements. In researching new and innovative vegetation control methods to add to its IVM Program, District efforts have included trial studies with UC Davis researchers using acetic acid (vinegar), barley straw and corn gluten, thermal steaming, burning, tarping, grazing and organic herbicide testing.

Phase 1 Pilot Study

In 2017, NID initiated evaluation of alternative strategies to vegetation management through a Pilot Study (Phase 1). Phase 1 included two activities: 1) review and coordination with the Vegetation Management Working Group and 2) field testing of alternative herbicides and mechanical approaches.

The Vegetation Management Working Group comprised local farmers, ranchers, representatives of the agricultural industry and others (such as the Placer and Nevada County Ag Commissioners and the Nevada County Resource Conservation District). NID convened the group to obtain information and guidance regarding integrated approaches to vegetation management. The group met several times and provided information and guidance for the field-testing portion of Phase 1.

In fall of 2017, District staff and consultants designed a pilot field study and prepared a grant proposal for submission to the Department of Pesticide Regulation's Research Grants Program. Although the grant was not awarded, the process of developing the application helped the District to establish an IVM team and catalyzed the field study efforts. Beginning in spring 2018, the District initiated a Phase 1 field test of alternative herbicides, biological and mechanical treatment methods. The study design included

application, data collection and data analysis of treatment efficacy based on percent control and percent cover. Nine organic herbicides, two mechanical treatment methods (mowing and abrasion weeder) and goat grazing were tested. Phase 1 identified a number of organic herbicides that produced greater measurable results to support additional trial testing and served to collect cost and efficacy information on mechanical and grazing treatments.

Phase 2 Study

In 2018, NID initiated a Phase 2 Study that expanded the trials of alternative herbicides that demonstrated the greatest measurable results in Phase 1. The Phase 2 Study also included mechanical treatment using steam and burn treatments, as well as analysis of native vegetation plantings. The results of the Phase 2 Study identified Opportune, Weed Slayer and Scythe as the top performing alternatives. Results of the Phase 2 Study supported continued study of the top performing alternatives along longer segments of canals and a study of the costs of removing glyphosate from the District IVM Program.

Although the Phase 2 Study mechanical treatments (steam and flame) demonstrated application rates 15 to 30 times longer than current method application rates, the District is committed to continuing its collaboration with the vendor to explore fabrication of a boom style arm for more practical application. In addition, the District has continued monitoring of the native plantings and found significant overgrowth of the plantings which has required labor-intensive manual cutting and removal of the subsequent material off-site.

INTRODUCTION

The District IVM Program has maintained steady efforts in research and investigation of new and innovative vegetation control tools and techniques. In 2019, NID initiated a Phase 3 Study to evaluate the efficacy of Opportune, Weed Slayer and Scythe herbicides along segments of the District's Combie Phase III Canal and Auburn Ravine II Canal. As Opportune, Weed Slayer and Scythe were identified as the top performing alternative herbicides of the Phase 2 Study they were applied in trial applications along the test segments of the Combie Phase III Canal and Auburn Ravine II Canal.

MATERIALS AND METHODS

Study Plot Locations

The Phase 3 Study test plots were established on the Combie Phase III and Auburn Ravine II Canals. These sites were selected as the test plot locations because of the uniformity of vegetation type and density along contiguous segments of canal. The Phase 3 Study focused on two test plot segments due to the limited availability of the organic product Opportune. Opportune has yet to be released on the market.

The test site on the Combie Phase III Canal is located in Nevada County, at an elevation of 1,280 feet in a grassland vegetation type. The test site on the Auburn Ravine II Canal is located in Placer County, at an elevation of 340 feet in a grassland vegetation type. Each plot was 660 feet long and 8 feet wide. Table 1 provides Phase 3 trial locations summary information.

Table 1: Phase 3 Application Sites

Test Site	Elev. (FT)	Nearest City	County	Plot Acreage	Vegetation & Soil Type
Auburn Ravine II Canal	340	Newcastle	Placer	0.12	Vegetation Mediterranean California naturalized annual and perennial grassland [CNDDDB] Soil Caperton-Andregg course sandy loams [NRCS]
Combie Phase III Canal	1,280	Grass Valley	Nevada	0.12	Vegetation California naturalized annual and perennial grassland [CNDDDB] Soil Auburn-Rock outcrop complex [NRCS]

Alternative Herbicides Applications

The Phase 3 Study included Opportune, Weed Slayer and Scythe – the top performing alternative herbicides identified through the Phase 2 Study. Table 2 provides summary information about Opportune, Weed Slayer and Scythe. Table 3 lists application rates and product cost per acre for each alternative herbicide.

Table 2: Phase 3 Alternative Herbicides Summary Information

Product	Active Ingredient	EPA Signal Word ¹	Required Personal Protective Equipment
Opportune	Microbial compound (dead, non-viable <i>Streptomyces acidiscabies</i> strain RL-110T cells and spent fermentation media)	Caution	Long sleeve shirt, long Pants, shoes plus socks waterproof gloves, filtering face piece respirator
Scythe	Pelargonic Acid	Warning	Coveralls over short-sleeve shirt and short pants, chemical resistant-gloves, chemical-resistant footwear plus socks and protective eyewear
Weed Slayer	Eugenol (essential oil of clove) and molasses	Exempt	Safety glasses an gloves

Table 3: Application Rates and Costs per Acre for Each Alternative Herbicides

Product	Recommended Application Rate	Cost per Acre ²	Vendor
Opportune	3 gallons/acre	Unavailable	Marrone Bio innovations
Scythe	7% concentrate	\$1,539.00	Gowan Company
Weed Slayer	32 oz. Part A/acre plus 32 oz. Part B (surfactant)/acre	\$138.75	Agro Research Intl. LLC

¹ Federal regulation group pesticides into three categories according to toxicity and potential to injure people or the environment: DANGER, WARNING or CAUTION. Pesticides labels indicate these categories to show a product potential to cause injury if not used according to label instructions. Products with the signal word CAUTION are lower in toxicity and indicate the product is slightly toxic if eaten, absorbed through the skin, inhaled, or it causes slight eye or skin irritation. Products with the signal word WARNING indicate the pesticide is moderately toxic if eaten, absorbed through the skin, inhaled, or it causes moderate eye or skin irritation. DANGER means the product is highly toxic by at least one route of exposure – it may be corrosive, causing irreversible damage to the skin or eyes; and/or it may be highly toxic if eaten, absorbed through the skin, or inhaled.

² Cost per acre is calculated assuming 30 gallons of solution applied per acre.

District staff performed Phase 3 Study applications using a side-by-side boom sprayer. District staff mixed and applied the study herbicides according to the recommended protocol provided after the Phase 2 Study. District staff followed regulated material label and safety data sheet (SDS) instructions for use of personal protective equipment (PPE) during mixing and application and also adhered to the label and SDS specified environmental condition application limitations (e.g., wet and/or windy conditions).

Table 4 provides a summary of Phase 3 Study alternative herbicide applications.

Table 4: Phase 3 Alternative Herbicides Applications

Date	Location & Activity	Alternative Herbicide Applied
2019.12.05	Auburn Ravine II – Application #1	Opportune + Weed Slayer
2019.12.05	Combie Phase III – Application #1	Opportune + Weed Slayer
2020.01.10	Auburn Ravine II – Application #2	Opportune + Weed Slayer
2020.01.10	Combie Phase III – Application #2	Opportune + Weed Slayer
2020.03.06	Auburn Ravine II – Application #3	Scythe
2020.03.06	Combie Phase III – Application #3	Scythe

Monitoring and Data Collection

Monitoring and evaluating effectiveness of a treatment used the observed effect method to replicate the common field practice used for its efficiency of implementation. District staff monitored and evaluated the sites using the observed effect evaluation criteria also used during the Phase 2 Study. This observed effect monitoring evaluates percent control of vegetation, estimating overall plant response to the applied products based on set criteria categories as defined in Table 5.

Table 5: Phase 2 & 3 Study Percent Control Evaluation Criteria

% Impact	Observed Effect
0%	No effect.
10%	Minor plant stunting or curling of leaves and stems.
20%	Stunting or curling is more pronounced and plant is still mostly green.
30%	Leaf margin or chlorosis increase to approximately 1/3 of plant surface.
40%	Symptoms have increased with more severe leaf chlorosis but affecting less than 50% of plant surface or population in the treatment area.
50%	Approximately half of the weeds present in the treatment area display stunting, curling, chlorosis and/or necrosis on 50% of the plant leaves or stems.
60%	Slightly more than half of the weed population present in the treatment area display severe chlorosis or necrosis.
70%	Chlorosis and/or necrosis symptoms now present on most plants but still about 30% of plant tissue is green.
80%	Symptoms have expanded or increased to a majority of plants present but some still functioning tissue.
90%	A majority of plants in the treatment zone are displaying complete mortality but a few remaining plants have not been completely killed.
100%	All plants in treatment area are completely affected by the treatment and are dead.

Table 6 provides the categories used to further describe the range of control based on the observed percent impact.

Table 6: Range of Control Categories

% Impact Range	Category
0 – 50%	Poor Control (P)
51 – 80%	Fair Control (F)
80 - 95%	Good Control (G)
96 – 100%	Excellent Control (E)

Effort was made to collect data along the test sites at intervals close to 7, 14, 28, 45 and 60 days after application. Table 7 provides a summary of Phase 3 Study monitoring and evaluations events.

Table 7: Phase 3 Monitoring and Evaluation Dates

Date	Location & Activity
2019.12.11	Auburn Ravine II – Monitoring and Evaluation #1
2019.12.11	Combie Phase III – Monitoring and Evaluation #1
2019.12.19	Auburn Ravine II – Monitoring and Evaluation #2
2019.12.19	Combie Phase III – Monitoring and Evaluation #2
2020.01.06	Auburn Ravine II – Monitoring and Evaluation #3
2020.01.06	Combie Phase III – Monitoring and Evaluation #3
2020.01.21	Auburn Ravine II – Monitoring and Evaluation #4
2020.01.21 & 22	Combie Phase III – Monitoring and Evaluation #4
2020.02.07	Auburn Ravine II – Monitoring and Evaluation #5
2020.02.07	Combie Phase III – Monitoring and Evaluation #5
2020.03.05	Auburn Ravine II – Monitoring and Evaluation #6
2020.03.05	Combie Phase III – Monitoring and Evaluation #6
2020.03.12	Auburn Ravine II – Monitoring and Evaluation #7
2020.03.12	Combie Phase III – Monitoring and Evaluation #7
2020.03.30	Auburn Ravine II – Monitoring and Evaluation #8
2020.03.30	Combie Phase III – Monitoring and Evaluation #8
2020.04.28	Auburn Ravine II – Monitoring and Evaluation #9
2020.04.28	Combie Phase III – Monitoring and Evaluation #9

Data Analysis

As prescribed by the protocol that was informed and developed out of the Phase 2 Study, the Phase 3 data analysis was designed to show the efficacy of the alternative herbicide applications over greater study plot areas over time. Using the monitoring data collected, the analysis provided the opportunity to develop and forecast an alternative herbicide application schedule with the goal of fulfilling the necessary range of vegetation control that supports water quality and health, reliable delivery to customers, employee safety and wildfire prevention.

The following tables and graphs provide summary of the percent control data collected over the course of the Phase 3 Study. Line graphs display the range of control observed with the specific alternative herbicide application dates. Presenting the range of control data with the application dates aid in understanding the responsiveness of vegetation to the alternative herbicide applications, identify trends useful in forecasting control and consider the application schedule necessary to meet control targets.

Table 8: Percent Control Observed at Auburn Ravine II Canal

PLOT	DATE								
	Dec. 11, 2019	Dec. 19, 2019	January 6, 2020	January 21, 2020	February 7, 2020	March 5, 2020	March 12, 2020	March 30, 2020	April 28, 2020
AR2-01	10	70	10	80	90	0	50	80	0
AR2-02	70	70	10	80	80	0	60	60	0
AR2-03	70	70	10	80	70	0	30	60	0
AR2-04	70	70	10	70	90	0	60	20	0
AR2-05	10	70	10	90	80	0	70	20	0
AR2-06	20	70	20	90	90	0	70	40	0
AR2-07	20	70	10	50	60	0	60	30	0
AR2-08	20	70	15	80	60	0	70	70	0
AR2-09	20	50	15	85	90	0	70	40	0
AR2-10	20	60	10	50	90	0	40	30	0
AR2-11	10	40	5	70	60	0	40	40	0
AR2-12	10	10	10	50	50	0	30	10	0
AR2-13	10	20	10	50	50	0	65	30	0
AR2-14	10	20	5	75	50	0	40	10	0
AR2-15	10	10	5	90	90	0	70	10	0
AVERAGE	25	51	10	73	73	0	55	37	0

Graph 1: Percent Control Observed at Auburn Ravine II Canal

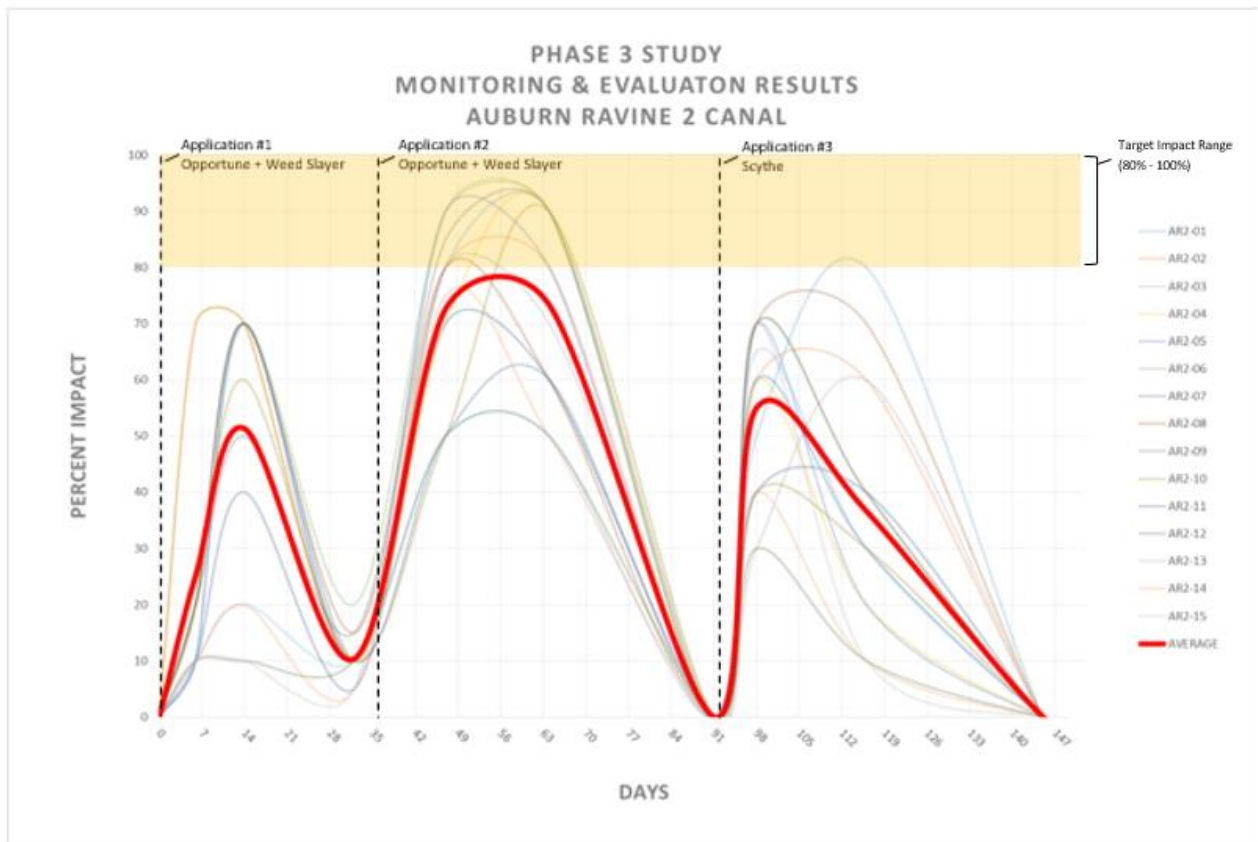
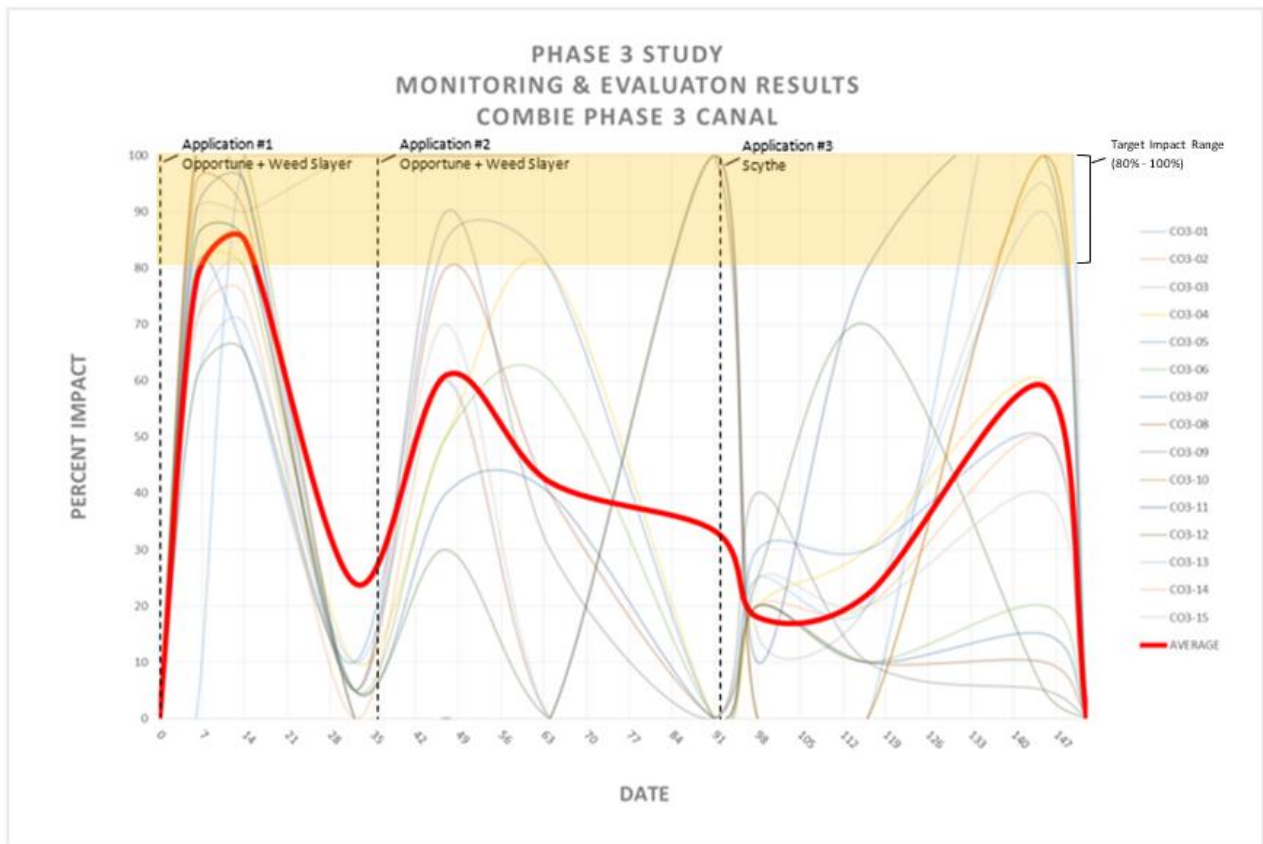


Table 9: Percent Control Observed at Combie Phase III Canal

PLOT	DATE								
	Dec. 11, 2019	Dec. 19, 2019	January 6, 2020	January 21&22, 2020	February 7, 2020	March 5, 2020	March 12, 2020	March 30, 2020	April 28, 2020
CO3-01	100	100	100	0	100	100	0	0	100
CO3-02	100	100	100	0	100	100	0	0	100
CO3-03	90	90	100	0	100	100	15	20	95
CO3-04	80	80	10	50	80	0	20	30	60
CO3-05	80	65	10	85	80	0	30	30	50
CO3-06	85	85	5	50	60	0	20	10	20
CO3-07	85	85	5	40	40	0	20	10	15
CO3-08	95	90	5	80	40	0	20	10	10
CO3-09	100	95	5	90	30	0	40	10	5
CO3-10	100	100	0	0	0	100	0	0	100
CO3-11	90	95	0	0	0	100	10	80	100
CO3-12	60	65	5	30	0	0	25	70	5
CO3-13	60	70	10	60	0	0	25	20	90
CO3-14	70	75	0	60	0	0	20	20	50
CO3-15	70	80	5	70	0	0	25	20	40
AVERAGE	84	85	24	41	42	33	18	22	56

Graph 2: Percent Control Observed at Combie Phase III Canal



RESULTS AND DISCUSSION

The Phase 3 Study has provided useful data on the efficacy of the alternative herbicides when applied across a greater application area. The data collected from the Phase 3 Study also provided an understanding of the trend in vegetation responsiveness to the alternative herbicide application. Understanding the trend in vegetation response is necessary in forecasting control, developing an application plan and schedule that meets control thresholds, support water quality and health, reliable delivery to customers, employee safety and wildfire prevention.

In reviewing the data set and graph for each application location, the general trend in data showed three distinct vegetation response peaks at both Auburn Ravine II Canal and Combie Phase III Canal test locations. In further review of the Combie Phase III data, an unanticipated response peak appeared to occur towards the end of the study period rather than the anticipated response immediately after the third application. After further investigation and review of the data, it appears that the Combie Phase III test site was likely exhibiting vegetation control influence from prior years' non-study related pre-emergent applications.

Although the Phase 3 alternative herbicide applications did not result in average impact ranges within target impact ranges (80% - 100%) supportive of water quality and health, reliable delivery to customers, employee safety and wildfire prevention – a modified protocol with increased application frequency may demonstrate and possibly sustain results of vegetation response in the target impact range. An increased application frequency will result in increased demand on resources including material and labor that must be considered in any future protocol development. In addition, the unavailability of the Opportune alternative herbicide on the market must also be considered in the development of a future test protocol.

RECOMMENDATIONS

Based on the data analysis, it is recommended that the District maintained its research and investigation efforts in identifying and testing alternative vegetation control methods including alternative herbicides and mechanical treatments. Specifically, it is recommended that the District study the use of Weed Slayer and Scythe alternative herbicides under a protocol with increased application frequency to investigate the ability and resources necessary to meet an average target impact range (80% - 100%) supportive of water quality and health, reliable delivery to customers, employee safety and wildfire prevention.

LIST OF APPENDICES

- A. Product Label