CASITAS MUNICIPAL WATER DISTRICT

REQUEST FOR PROPOSAL

HYDROGRAPHIC AND LAND SURVEY SERVICES
LAKE CASITAS
October 13, 2016

1. **INTRODUCTION**

The Casitas Municipal Water District is requesting proposals to determine the current volume of Lake Casitas. It is the District's intent to receive proposals and cost statements that includes all technical and contractor services to provide labor, materials, and equipment to be applied in the work that is described by this Request for Proposal. It is expected that upon successful selection and approval of the proposal by the District, the proposing firm and the District will enter into a purchase order contract for the project.

2. **PROPOSAL SUBMITTAL**

The proposal should be submitted in written form to Casitas Municipal Water District, 1055 North Ventura Avenue, Oak View, California 93022, Attention: Neil Cole. Proposals will be accepted until **Wednesday, November 10, 2016 @ 4:00 P.M.** No proposals will be accepted after that time and date. The consultant shall provide one copy of the proposal. The copy can be submitted by email in Adobe Acrobat format to ncole@casitaswater.com.

3. **BACKGROUND**

Lake Casitas is located in northwest Ventura County near the community of Oak View. Casitas Dam was completed by the Bureau of Reclamation in 1959, forming Lake Casitas. Lake Casitas, when at spill elevation, is a 250,000 acre feet water reservoir with a surface area of 2700 acres. As of September 30, 2016, the lake was at elevation 489.00 with 93,464 acre feet of water in storage.

The District determines the volume of water stored in Lake Casitas based on the elevation and a rating table that was originally developed by the U.S. Bureau of Reclamation. Concern has been expressed about how much silt has accumulated in the lake and how accurate the current table is given any silt accumulation.

4. **PROJECT AND SCOPE**

The project and scope of work for this project consist of the following elements:

(1) Conduct a hydrographic survey of the portion of the lake that is currently wet.

(2) Conduct a land based survey of the dry portion of the lake from the current waterline to the spill elevation.

(3) Develop a new rating table for the lake based on the results of (1) & (2) above.

5. **SPECIAL CONDITIONS**

The District has provided the following project scope to assist in clarifying its intent on what the completed project should contain. Although, it should be noted by the Firm that there

may be some elements that are added to the scope of work, and which the Firm should consider during the preparation of the proposal.

Firm Requirements. It is contemplated that the selected firm will provide all equipment, personnel, mobilization, analysis, administration and other work necessary to complete the required. **The District is willing to provide a boat to complete the hydrographic survey**. The selected firm will be charged with the task of acquiring and scheduling all materials, labor and equipment, and for all other efforts required to complete the project. The following requirements are to be applied to the project:

(1) The project is a professional services contract unrelated to a construction project. Therefore, it is not a Public Works Contract.

(2) All work shall be performed in conformance with general industry safety orders of the State of California, Title 8 of Chapter 7, and safety standards set forth by the Occupational Safety and Health Agency (OSHA).

(3) The work shall be completed under the direction of a person licensed to performed surveys in the State of California.

Lake Casitas has the most stringent quagga mussel inspection in California. Lake Casitas requires all vessels entering the lake to undergo a quagga mussel inspection and a 35 day quarantine period. There is an alternate procedure for special circumstances. In all instances, the vessel shall be completely clean and dry. The vessel shall not have been in quagga infested waters. The District is willing to provide a vessel to complete the hydrographic survey.

Attached are the current rating table for Lake Casitas and the original topography map for the lake. The current lake water level is available at www.casitaswater.org.

6. **PROPOSAL CONTENT**

It is the intent of this Request for Proposal to seek only those proposals that will directly address the particular project of Casitas Municipal Water District. The firms being requested to submit proposals need not provide any general information about the firm, but only that particular information that specifically addresses the needs of this proposal. The proposal should not contain any information on the people involved in the project other than those who are actually going to be performing the work and are considered a primary human resource for the project. The scope provided by the proposal should address not only the details in the Request for Proposal, but should also address those issues and relative points that may not have been described in the Request for Proposal, which the firm believes to be pertinent to this particular project specified. The proposal should contain the following elements:

(a) Experience. The proposal content should begin with the experience the firm and personnel have with projects similar to that proposed by the District and name(s) of the license survey personnel that will be responsible for completing the work. The firm should submit a listing of the references with names and phone numbers of each similar project the Contractor has performed over the past five years. The firm shall provide a listing of all subcontractors whose work has a monetary value of fifteen percent (15%) or more of the total proposal price and shall include their reference experience as required of the primary contractor.

(b) Scope of Work. The proposal shall contain a description of the scope of work and how the firm intends to approach the project task and complete the scope of work in a timely manner. The firm shall provide a listing of those services to be provided during the course of the work and contribute to the cost element of the project. As a minimum, the proposal shall state the proposed cross section spacing. Fifty (50) foot or less cross section spacing is anticipated to achieve the accuracy needed to prepare a valid rating table. The proposal may include different levels of accuracy with a different fee assigned to both. The proposal shall recommend a level of accuracy, based on the firm's experience and understanding of the District's needs. The land portion of the survey can be completed by any method that will provide the desired accuracy.

(d) Work Plan and Time Frame. The proposal should include a work plan and time frame for the work. The work should be performed in a way as to minimize the disruption to the District's current operations, including, but not limited to, no work on such days as recognized as state or federal holidays. The firm shall indicate those items that are critical path and the firm's perception of the time schedule for implementing the project.

(e) Fee. The proposal shall provide a budget for each phase and project component of the project that ultimately provides a maximum lump sum fee for the completed project. The maximum lump sum fee shall be individually specified for each phase of the work. Factors for overhead should be included in the rate for hours counted for and billed. The maximum lump sum fee shall be an amount by which the selected firm can complete the entire project, including but not limited to taxes, shipping and handling costs, transportation costs, labor, equipment, materials, and any other cost charges for the scope of the project. Any request for additional fee payments, without timely notification by the firm and prior written approval by the District of a Change Order, will not be honored by the District.

Costs shall be provided as a minimum, for the following phases:

Phase 1-Hydrographic survey with current volume calculation.
Phase 2-Survey between current water surface elevation and lake spill elevation.
Phase 3-Preparation of a ratings table to the 100^{th} of a foot in elevation based on the new survey information.
Phase 4-Comparison between the new rating table and the original rating table. The comparison shall include a discussion of the likely causes for any discrepancy (i.e. sedimentation, error, improved accuracy with current equipment etc.).

(f) Conflicts. The firm shall identify any conflicts which they believe could affect the project work and the ability to complete on schedule.

7. PRE PROPOSAL CONFERENCE

There will not be any formal pre-proposal conference or formal interview prior to the selection of the firm. If the firm desires to visit the lake, the firm should arrange a field meeting with Neil Cole (805) 649-2251, Ext. 107.

8. SELECTION

The selection of the firm to complete the work will be based upon the following criteria:

(a) Qualifications and experience of the firm and primary human resources identified as being major human resources on the project.

(b) The thoroughness and thought put into the proposal and the detail of the scope of work provided by the firm.

(c) The proposed level of accuracy for the survey and rating table.

(b) The maximum fee, and hours specified by the firm to complete the scope of work.

(d) The ability of the Firm to complete the project in a timely manner.

The District reserves the right to reject any and all proposals that are considered unacceptable by the District or to waive any minor irregularities if so deemed by the District for any reason. If the District is unable to enter into agreement with the selected firm for any reason, it reserves the right to award the contract to the next lowest responsible firm who submitted a proposal. The same selection process would be used to select the alternate firm. The District reserves the right to retain all proposals for a period of thirty (30) days and to reject any and all proposals for any reason at the sole discretion of the District, with or without cause.

9. **CONTRACT**

It is expected that the selected firm will enter into a contract with the District to perform the work. The conditions to be included in that contract are as follows:

(a) A "no attorney's fees" clause.

(b) A "no interest" clause.

(c) That the District be provided with and retain ownership of all documents, product manuals, files, or other work generated in connection with this project.

(d) That the firm and any Subcontractor shall provide workmen's compensation insurance and liability insurance as specified in Casitas Municipal Water District Insurance & Indemnification Requirements (attached).

(e) That any review and discussion of the bills shall not be cause for extra cost or billings.

(f) Any dispute resulting in lawsuits shall be filed and processed in Ventura County in accordance with the laws of the State of California.

(g) The full and agreed upon project description as contained herein, or as revised.

(h) That the firm indemnifies the District in accordance with the provisions contained in Casitas Municipal Water District Insurance & Indemnification Requirements (attached).

10. **PAYMENT**

The District shall only accept one (1) payment request from the selected firm per month. Invoices shall fully define the work component completed, the hours spent on each task, the budget for that person in terms of cost and hours, the pay rate for which the person is assigned, the percentage of the task completed in terms of actual work remaining and costs remaining until completion of the task at the time of billing. Each bill shall also contain a purchase order number or work order number assigned to each task and the bill shall state the billing period. The bill will be paid within thirty (30) days after the approval by the District's Board of Directors.

11. **DISTRICT CONTACT**

Neil Cole
Principal Civil Engineer
Casitas Municipal Water District
1055 N. Ventura Avenue
Oak View California 93022
(805) 649-2251, Ext. 107
FAX: (805) 649-3001

CASITAS MUNICIPAL WATER DISTRICT

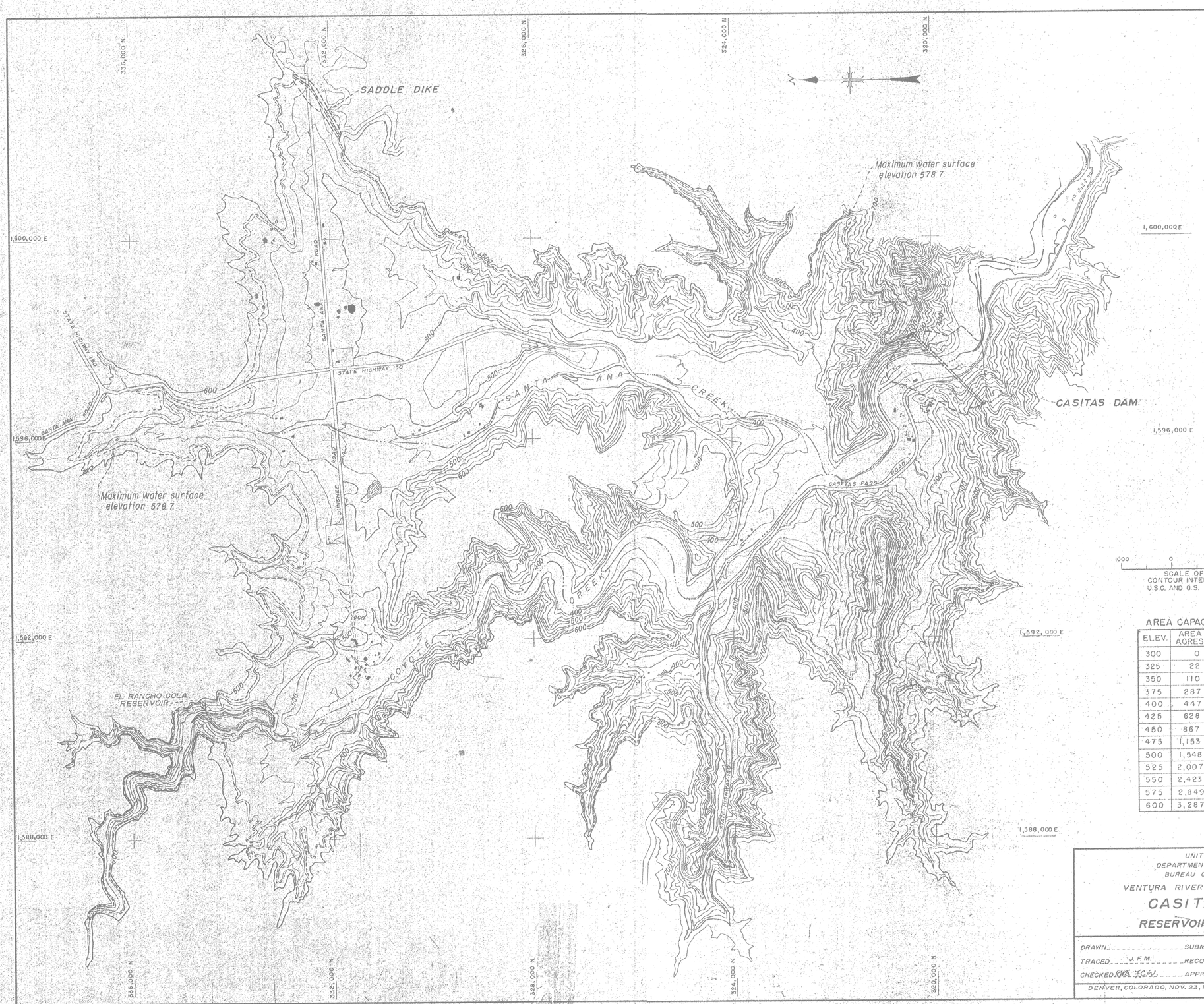
CAPACITIES OF CASITAS RESERVOIR

Compiled from Unites States Bureau of Reclamation tabulation dated December, 1958, with corrections for borrow pits.

Tabulation completed September, 1959

Elev. Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	Difference
					ACRE-FEET						
350	3,167	3,178	3,190	3,202	3,213	3,224	3,236	3,248	3,259	3,270	115
351	3,282	3,294	3,306	3,318	3,330	3,342	3,355	3,367	3,379	3,391	121
352	3,403	3,416	3,428	3,441	3,454	3,466	3,479	3,492	3,505	3,517	127
353	3,530	3,543	3,557	3,570	3,583	3,596	3,610	3,623	3,636	3,650	133
354	3,663	3,677	3,691	3,705	3,719	3,733	3,747	3,761	3,775	3,789	140
355	3,803	3,818	3,832	3,846	3,861	3,876	3,890	3,904	3,919	3,934	145
356	3,948	3,963	3,978	3,993	4,008	4,024	4,039	4,054	4,069	4,084	151
357	4,099	4,115	4,131	4,146	4,162	4,178	4,194	4,210	4,225	4,241	158
358	4,257	4,273	4,290	4,306	4,323	4,339	4,355	4,372	4,388	4,405	164
359	4,421	4,438	4,455	4,472	4,489	4,506	4,523	4,540	4,557	4,574	170
360	4,591	4,609	4,627	4,644	4,662	4,680	4,698	4,716	4,733	4,751	178
361	4,769	4,787	4,806	4,824	4,843	4,861	4,879	4,898	4,916	4,935	184
362	4,953	4,972	4,992	5,011	5,030	5,050	5,069	5,088	5,107	5,127	193
363	5,146	5,166	5,186	5,205	5,225	5,245	5,265	5,285	5,304	5,324	198
364	5,344	5,365	5,385	5,406	5,426	5,447	5,468	5,488	5,509	5,529	206
365	5,550	5,571	5,593	5,614	5,635	5,656	5,678	5,699	5,720	5,742	213
366	5,763	5,785	5,807	5,829	5,851	5,873	5,895	5,917	5,939	5,961	220
367	5,983	6,006	6,029	6,051	6,074	6,097	6,120	6,143	6,165	6,188	228
368	6,211	6,235	6,258	6,282	6,305	6,329	6,353	6,376	6,400	6,423	236
369	6,447	6,471	6,496	6,520	6,545	6,569	6,593	6,618	6,642	6,667	244
370	6,691	6,716	6,742	6,767	6,792	6,818	6,843	6,868	6,893	6,919	253
371	6,944	6,970	6,996	7,022	7,048	7,074	7,100	7,126	7,152	7,178	260
372	7,204	7,231	7,258	7,285	7,312	7,338	7,365	7,392	7,419	7,446	269
373	7,473	7,501	7,528	7,556	7,584	7,612	7,639	7,667	7,695	7,722	277
374	7,750	7,778	7,807	7,836	7,864	7,892	7,921	7,950	7,978	8,006	285
375	8,035	8,064	8,094	8,123	8,152	8,182	8,211	8,240	8,269	8,299	293
376	8,328	8,358	8,388	8,418	8,448	8,478	8,507	8,537	8,567	8,597	299
377	8,627	8,658	8,688	8,718	8,749	8,780	8,810	8,840	8,871	8,902	305
378	8,932	8,963	8,994	9,025	9,056	9,088	9,119	9,150	9,181	9,212	311
379	9,243	9,275	9,307	9,339	9,371	9,402	9,434	9,466	9,498	9,530	319
380	9,562	9,594	9,627	9,659	9,691	9,724	9,756	9,788	9,820	9,853	323
381	9,885	9,918	9,951	9,984	10,017	10,050	10,083	10,116	10,149	10,182	330
382	10,215	10,249	10,282	10,316	10,349	10,383	10,417	10,450	10,484	10,517	336
383	10,551	10,585	10,620	10,654	10,688	10,722	10,757	10,791	10,825	10,860	343
384	10,894	10,929	10,964	10,998	11,033	11,068	11,103	11,138	11,172	11,207	348
385	11,242	11,278	11,313	11,348	11,384	11,420	11,455	11,490	11,526	11,562	355
386	11,597	11,633	11,669	11,706	11,741	11,778	11,814	11,850	11,886	11,922	361
387	11,958	11,995	12,032	12,069	12,106	12,142	12,179	12,216	12,253	12,290	369
388	12,327	12,364	12,402	12,439	12,477	12,514	12,551	12,589	12,626	12,664	374
389	12,701	12,739	12,777	12,815	12,853	12,892	12,930	12,968	13,006	13,044	381
390	13,082	13,121	13,159	13,198	13,237	13,276	13,314	13,353	13,392	13,430	387
391	13,469	13,508	13,548	13,587	13,626	13,666	13,705	13,744	13,783	13,823	393
392	13,862	13,902	13,942	13,982	14,022	14,062	14,102	14,142	14,182	14,222	400
393	14,262	14,303	14,343	14,384	14,425	14,466	14,506	14,547	14,588	14,628	407
394	14,669	14,710	14,752	14,793	14,834	14,876	14,917	14,958	14,999	15,041	413
395	15,082	15,124	15,166	15,208	15,250	15,292	15,335	15,377	15,419	15,461	421
396	15,503	15,546	15,588	15,631	15,673	15,716	15,759	15,801	15,844	15,886	426
397	15,929	15,972	16,016	16,059	16,102	16,146	16,189	16,232	16,275	16,319	433
398	16,362	16,406	16,450	16,494	16,538	16,582	16,626	16,670	16,714	16,758	440
399	16,802	16,847	16,891	16,936	16,981	17,026	17,070	17,115	17,160	17,204	447
400	17,249	17,294	17,340	17,385	17,431	17,476	17,521	17,567	17,612	17,658	454
401	17,703	17,749	17,795	17,841	17,887	17,933	17,979	18,025	18,071	18,117	460
402	18,163	18,210	18,257	18,304	18,351	18,398	18,444	18,491	18,538	18,585	469
403	18,632	18,679	18,727	18,774	18,822	18,869	18,916	18,964	19,011	19,059	474
404	19,106	19,154	19,202	19,251	19,299	19,347	19,395	19,443	19,492	19,540	482
405	19,588	19,637	19,686	19,734	19,783	19,832	19,881	19,930	19,978	20,027	493

Elev. Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7		0.9	ence
					ACRE-FEET						
406	20,076	20,126	20,175	20,225	20,274	20,324	20,374	20,423	20,473	20,522	496
407	20,572	20,622	20,672	20,723	20,773	20,823	20,873	20,923	20,974	21,024	502
408	21,074	21,125	21,176	21,227	21,278	21,329	21,380	21,431	21,482	21,533	510
409	21,584	21,636	21,687	21,739	21,790	21,842	21,894	21,945	21,997	22,048	516
410	22,100	22,152	22,205	22,258	22,310	22,362	22,415	22,468	22,520	22,572	525
411	22,625	22,678	22,731	22,784	22,837	22,890	22,944	22,997	23,050	23,103	531
412	23,156	23,210	23,264	23,317	23,371	23,425	23,479	23,533	23,586	23,640	538
413	23,694	23,749	23,803	23,858	23,912	23,967	24,022	24,076	24,131	24,185	546
414	24,240	24,295	24,350	24,406	24,461	24,516	24,571	24,626	24,682	24,737	552
415	24,792	24,848	24,904	24,960	25,016	25,072	25,128	25,184	25,240	24,296	560
416	25,352	25,409	25,465	25,522	25,579	25,636	25,692	25,749	25,806	25,862	567
417	25,919	25,976	26,034	26,092	26,149	26,206	26,264	26,322	26,379	26,436	575
418	26,494	26,552	26,611	26,669	26,728	26,786	26,844	26,903	26,961	27,020	584
419	27,078	27,137	27,196	27,255	27,314	27,372	27,431	27,490	27,549	27,608	589
420	27,667	27,728	27,788	27,848	27,909	27,970	28,030	28,090	28,151	28,212	605
421	28,272	28,333	28,395	28,456	28,518	28,579	28,640	28,702	28,763	28,825	614
422	28,886	28,948	29,010	29,072	29,134	29,196	29,259	29,321	29,383	29,445	621
423	29,507	29,570	29,633	29,696	29,759	29,822	29,884	29,947	30,010	30,073	629
424	30,136	30,200	30,263	30,326	30,390	30,454	30,517	30,580	30,644	30,708	635
425	30,771	30,835	30,900	30,964	31,029	31,093	31,157	31,222	31,286	31,351	644
426	31,415	31,480	31,546	31,611	31,677	31,742	31,807	31,873	31,938	32,004	654
427	32,069	32,135	32,201	32,268	32,334	32,400	32,466	32,532	32,599	32,665	662
428	32,731	32,798	32,865	32,932	32,999	33,066	33,134	33,201	33,268	33,335	671
429	33,402	33,470	33,538	33,606	33,674	33,742	33,810	33,878	33,946	34,014	680
430	34,082	34,151	34,220	34,289	34,358	34,427	34,496	34,565	34,634	34,703	690
431	34,772	34,842	34,912	34,982	35,052	35,122	35,192	35,262	35,332	35,402	700
432	35,472	35,543	35,613	35,684	35,755	35,826	35,896	35,967	36,038	36,108	707
433	36,179	36,251	36,323	36,394	36,466	36,538	36,610	36,682	36,753	36,825	718
434	36,897	36,970	37,042	37,115	37,187	37,260	37,333	37,405	37,478	37,550	726
435	37,623	37,697	37,770	37,844	37,918	37,992	38,065	38,139	38,213	38,286	737
436	38,360	38,434	38,509	38,584	38,658	38,732	38,807	38,882	38,956	39,030	745
437	39,105	39,181	39,256	39,332	39,407	39,483	39,559	39,634	39,710	39,785	756
438	39,861	39,938	40,014	40,090	40,167	40,244	40,320	40,396	40,473	40,550	765
439	40,626	40,704	40,781	40,859	40,936	41,014	41,092	41,169	41,247	41,324	776
440	41,402	41,480	41,559	41,637	41,715	41,794	41,872	41,950	42,028	42,107	783
441	42,185	42,264	42,344	42,424	42,503	42,582	42,662	42,742	42,821	42,900	795
442	42,980	43,060	43,141	43,221	43,302	43,382	43,462	43,543	43,623	43,704	804
443	43,784	43,865	43,947	44,028	44,110	44,191	44,272	44,354	44,435	44,517	814
444	44,598	44,680	44,763	44,845	44,927	45,010	45,092	45,174	45,256	45,339	823
445	45,421	45,504	45,588	45,671	45,755	45,838	45,921	46,005	46,088	46,172	834
446	46,255	46,339	46,424	46,508	46,593	46,677	46,761	46,846	46,930	47,015	844
447	47,099	47,184	47,270	47,355	47,440	47,526	47,611	47,696	47,781	47,867	853
448	47,952	48,038	48,125	48,211	48,298	48,384	48,470	48,557	48,643	48,730	864
449	48,816	48,903	48,991	49,078	49,166	49,253	49,340	49,428	49,515	49,603	874
450	49,690	49,778	49,867	49,956	50,044	50,132	50,221	50,310	50,398	50,486	885
451	50,575	50,664	50,754	50,843	50,933	51,022	51,111	51,201	51,290	51,380	894
452	51,469	51,560	51,650	51,741	51,831	51,922	52,013	52,103	52,194	52,284	906
453	52,375	52,467	52,558	52,650	52,742	52,834	52,925	53,017	53,109	53,200	917
454	53,292	53,385	53,477	53,570	53,663	53,756	53,848	53,941	54,034	54,126	927
455	54,219	54,313	54,407	54,500	54,594	54,688	54,782	54,876	54,969	55,063	938
456	55,157	55,252	55,347	55,442	55,537	55,632	55,727	55,822	55,917	56,012	950
457	56,107	56,203	56,299	56,395	56,491	56,588	56,684	56,780	56,876	56,972	961
458	57,068	57,165	57,263	57,360	57,457	57,555	57,652	57,749	57,846	57,944	973
459	58,041	58,139	58,237	58,336	58,434	58,532	58,630	58,728	58,827	58,925	982
460	59,023	59,122	59,222	59,322	59,421	59,520	59,620	59,720	59,819	59,918	995
461	60,018	60,119	60,219	60,320	60,420	60,521	60,622	60,722	60,823	60,923	1,006
462	61,024	61,126	61,228	61,329	61,431	61,533	61,635	61,737	61,838	61,940	1,018
463	62,042	62,145	62,248	62,351	62,454	62,556	62,659	62,762	62,865	62,968	1,029
464	63,071	63,175	63,279	63,383	63,487	63,591	63,695	63,799	63,903	64,007	1,040
465	64,111	64,216	64,321	64,427	64,532	64,637	64,742	64,847	64,953	65,058	1,052
466	65,163	65,269	65,376	65,482	65,589	65,695	65,801	65,908	66,014	66,121	1,064
467	66,227	66,334	66,442	66,550	66,657	66,764	66,872	66,980	67,087	67,194	1,075
468	67,302	67,411	67,519	67,628	67,737	67,846	67,954	68,063	68,172	68,280	1,087
469	68,389	68,499	68,609	68,719	68,829	68,938	69,048	69,158	69,268	69,378	1,098
470	69,488	69,598	69,708	69,819	69,929	70,039	70,149	70,259	70,369	70,479	1,109



1000 0 1000 2000

SCALE OF FEET
CONTOUR INTERVAL - 25 FEET
U.S.C. AND G.S. 1929 DATUM

AREA CAPACITY TABLE

ELEV.	AREA ACRES	CAPACITY ACRE FEET
300	0	0
325	22	275
350	110	1,925
375	287	6,888
400	447	16,063
425	628	29,500
450	867	48,188
475	1,153	73,438
500	1,548	107,200
525	2,007	151,638
550	2,423	207,013
575	2,849	272,913
600	3,287	349,613

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
VENTURA RIVER PROJECT - CALIFORNIA

CASITAS DAM

RESERVOIR AREA MAP

DRAWN		SUBMITTED	O. F. Rice
TRACED	V. F. M.	RECOMMENDED	J. M. Keener
CHECKED	[illegible]	APPROVED	Grant Bloodgood, ASSOCIATE CHIEF ENGINEER

DENVER, COLORADO, NOV. 23, 1955 — 767-D-5

Spec. DC 4701

6-162

Chart to Calculate Storage to the Hundreths Place (Acre Feet)

Elev.	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
471.0	70626	70638	70649	70661	70672	70684	70695	70707	70718	70730
471.1	70741	70753	70764	70776	70787	70799	70810	70822	70833	70845
471.2	70856	70868	70879	70891	70902	70914	70925	70937	70948	70960
471.3	70971	70983	70994	71006	71017	71029	71040	71052	71063	71075
471.4	71086	71098	71109	71121	71132	71144	71155	71167	71178	71190
471.5	71201	71213	71224	71236	71247	71259	71270	71282	71293	71305
471.6	71316	71328	71339	71351	71362	71374	71385	71397	71408	71420
471.7	71431	71443	71454	71466	71477	71489	71500	71512	71523	71535
471.8	71546	71558	71569	71581	71592	71604	71615	71627	71638	71650
471.9	71661	71673	71684	71696	71707	71719	71730	71742	71753	71765
472.0	71776	71788	71799	71811	71822	71834	71845	71857	71868	71880
472.1	71892	71904	71915	71927	71938	71950	71962	71973	71985	71996
472.2	72008	72020	72031	72043	72054	72066	72078	72089	72101	72112
472.3	72125	72137	72148	72160	72172	72184	72195	72207	72219	72230
472.4	72241	72253	72264	72276	72287	72299	72311	72322	72334	72345
472.5	72358	72370	72381	72393	72405	72417	72428	72440	72452	72463
472.6	72474	72486	72497	72509	72520	72532	72544	72555	72567	72578
472.7	72590	72602	72613	72625	72636	72648	72660	72671	72683	72694
472.8	72706	72718	72729	72741	72752	72764	72776	72787	72799	72810
472.9	72823	72835	72846	72858	72870	72882	72893	72905	72917	72928
473.0	72939	72951	72962	72974	72985	72997	73009	73020	73032	73043
473.1	73056	73068	73079	73091	73103	73115	73126	73138	73150	73161
473.2	73174	73186	73198	73209	73221	73233	73245	73257	73268	73280
473.3	73291	73303	73314	73326	73338	73350	73361	73373	73385	73396
473.4	73409	73421	73433	73444	73456	73468	73480	73492	73503	73515
473.5	73526	73538	73549	73561	73573	73585	73596	73608	73620	73631
473.6	73643	73655	73666	73678	73690	73702	73713	73725	73737	73748
473.7	73761	73773	73785	73796	73808	73820	73832	73844	73855	73867
473.8	73878	73890	73901	73913	73925	73937	73948	73960	73972	73983
473.9	73996	74008	74020	74031	74043	74055	74067	74079	74090	74102
474.0	74113	74125	74136	74148	74160	74172	74183	74195	74207	74218
474.1	74232	74244	74256	74268	74280	74292	74303	74315	74327	74339
474.2	74350	74362	74374	74385	74397	74409	74421	74433	74444	74456
474.3	74469	74481	74493	74505	74517	74529	74540	74552	74564	74576
474.4	74587	74599	74611	74622	74634	74646	74658	74670	74681	74693
474.5	74706	74718	74730	74742	74754	74766	74777	74789	74801	74813
474.6	74825	74837	74849	74861	74873	74885	74896	74908	74920	74932
474.7	74943	74955	74967	74978	74990	75002	75014	75026	75037	75049
474.8	75062	75074	75086	75098	75110	75122	75133	75145	75157	75169
474.9	75180	75192	75204	75215	75227	75239	75251	75263	75274	75286
475.0	75299	75311	75323	75335	75347	75359	75370	75382	75394	75406
475.1	75419	75431	75443	75455	75467	75479	75491	75503	75515	75527
475.2	75539	75551	75563	75575	75587	75599	75611	75623	75635	75647
475.3	75659	75671	75683	75695	75707	75719	75731	75743	75755	75767
475.4	75779	75791	75803	75815	75827	75839	75851	75863	75875	75887
475.5	75898	75910	75922	75934	75946	75958	75969	75981	75993	76005
475.6	76018	76030	76042	76054	76066	76078	76090	76102	76114	76126
475.7	76139	76151	76163	76175	76187	76200	76212	76224	76236	76248
475.8	76258	76270	76282	76294	76306	76318	76329	76341	76353	76365
475.9	76378	76390	76402	76414	76426	76438	76450	76462	76474	76486
476.0	76498	76510	76522	76534	76546	76558	76570	76582	76594	76606
476.1	76620	76632	76644	76657	76669	76681	76693	76705	76718	76730
476.2	76741	76753	76765	76777	76789	76802	76814	76826	76838	76850

476.3	76862	76874	76886	76898	76910	76923	76935	76947	76959	76971
476.4	76984	76996	77008	77021	77033	77045	77057	77069	77082	77094
476.5	77106	77118	77130	77143	77155	77167	77179	77191	77204	77216
476.6	77227	77239	77251	77263	77275	77288	77300	77312	77324	77336
476.7	77348	77360	77372	77384	77396	77409	77421	77433	77445	77457
476.8	77470	77482	77494	77507	77519	77531	77543	77555	77568	77580
476.9	77592	77604	77616	77629	77641	77653	77665	77677	77690	77702
477.0	77713	77725	77737	77749	77761	77774	77786	77798	77810	77822
477.1	77836	77848	77861	77873	77885	77898	77910	77922	77934	77947
477.2	77960	77972	77985	77997	78010	78022	78034	78047	78059	78072
477.3	78082	78094	78106	78119	78131	78143	78155	78167	78180	78192
477.4	78205	78217	78230	78242	78254	78267	78279	78291	78303	78316
477.5	78328	78340	78353	78365	78377	78390	78402	78414	78426	78439
477.6	78450	78462	78474	78487	78499	78511	78523	78535	78548	78560
477.7	78573	78585	78598	78610	78622	78635	78647	78659	78671	78684
477.8	78696	78708	78721	78733	78745	78758	78770	78782	78794	78807
477.9	78820	78832	78845	78857	78870	78882	78894	78907	78919	78932
478.0	78942	78954	78966	78979	78991	79003	79015	79027	79040	79052
478.1	79066	79078	79091	79103	79116	79128	79140	79153	79165	79178
478.2	79191	79204	79216	79229	79241	79254	79266	79279	79291	79304
478.3	79315	79327	79340	79352	79365	79377	79389	79402	79414	79427
478.4	79439	79451	79464	79476	79489	79501	79513	79526	79538	79551
478.5	79564	79577	79589	79602	79614	79627	79639	79652	79664	79677
478.6	79688	79700	79713	79725	79738	79750	79762	79775	79787	79800
478.7	79812	79824	79837	79849	79862	79874	79886	79899	79911	79924
478.8	79936	79948	79961	79973	79986	79998	80010	80023	80035	80048
478.9	80061	80074	80086	80099	80111	80124	80136	80149	80161	80174
479.0	80185	80197	80210	80222	80235	80247	80259	80272	80284	80297
479.1	80311	80324	80336	80349	80361	80374	80387	80399	80412	80424
479.2	80437	80450	80462	80475	80487	80500	80513	80525	80538	80550
479.3	80563	80576	80588	80601	80613	80626	80639	80651	80664	80676
479.4	80689	80702	80714	80727	80739	80752	80765	80777	80790	80802
479.5	80814	80827	80839	80852	80864	80877	80889	80902	80914	80927
479.6	80940	80953	80965	80978	80990	81003	81016	81028	81041	81053
479.7	81066	81079	81091	81104	81116	81129	81142	81154	81167	81179
479.8	81192	81205	81217	81230	81242	81255	81268	81280	81293	81305
479.9	81318	81331	81343	81356	81368	81381	81394	81406	81419	81431
480.0	81444	81457	81469	81482	81494	81507	81520	81532	81545	81557
480.1	81571	81584	81596	81609	81622	81635	81647	81660	81673	81685
480.2	81699	81712	81725	81737	81750	81763	81776	81789	81801	81814
480.3	81826	81839	81851	81864	81877	81890	81902	81915	81928	81940
480.4	81954	81967	81980	81992	82005	82018	82031	82044	82056	82069
480.5	82081	82094	82106	82119	82132	82145	82157	82170	82183	82195
480.6	82208	82221	82233	82246	82259	82272	82284	82297	82310	82322
480.7	82336	82349	82362	82374	82387	82400	82413	82426	82438	82451
480.8	82463	82476	82488	82501	82514	82527	82539	82552	82565	82577
480.9	82591	82604	82617	82629	82642	82655	82668	82681	82693	82706
481.0	82718	82731	82743	82756	82769	82782	82794	82807	82820	82832
481.1	82847	82860	82873	82886	82899	82912	82924	82937	82950	82963
481.2	82976	82989	83002	83015	83028	83041	83053	83066	83079	83092
481.3	83105	83118	83131	83144	83157	83170	83182	83195	83208	83221
481.4	83234	83247	83260	83273	83286	83299	83311	83324	83337	83350
481.5	83362	83375	83388	83400	83413	83426	83439	83452	83464	83477
481.6	83491	83504	83517	83530	83543	83556	83568	83581	83594	83607
481.7	83620	83633	83646	83659	83672	83685	83697	83710	83723	83736
481.8	83749	83762	83775	83788	83801	83814	83826	83839	83852	83865

481.9	83878	83891	83904	83917	83930	83943	83955	83968	83981	83994
482.0	84007	84020	84033	84046	84059	84072	84084	84097	84110	84123
482.1	84137	84150	84163	84176	84189	84202	84215	84228	84241	84254
482.2	84268	84281	84294	84307	84320	84334	84347	84360	84373	84386
482.3	84398	84411	84424	84437	84450	84463	84476	84489	84502	84515
482.4	84529	84542	84555	84568	84581	84595	84608	84621	84634	84647
482.5	84659	84672	84685	84698	84711	84724	84737	84750	84763	84776
482.6	84789	84802	84815	84828	84841	84854	84867	84880	84893	84906
482.7	84920	84933	84946	84959	84972	84986	84999	85012	85025	85038
482.8	85050	85063	85076	85089	85102	85115	85128	85141	85154	85167
482.9	85181	85194	85207	85220	85233	85247	85260	85273	85286	85299
483.0	85311	85324	85337	85350	85363	85376	85389	85402	85415	85428
483.1	85443	85456	85469	85483	85496	85509	85522	85535	85549	85562
483.2	85575	85588	85601	85615	85628	85641	85654	85667	85681	85694
483.3	85707	85720	85733	85747	85760	85773	85786	85799	85813	85826
483.4	85839	85852	85865	85879	85892	85905	85918	85931	85945	85958
483.5	85970	85983	85996	86009	86022	86036	86049	86062	86075	86088
483.6	86102	86115	86128	86142	86155	86168	86181	86194	86208	86221
483.7	86234	86247	86260	86274	86287	86300	86313	86326	86340	86353
483.8	86366	86379	86392	86406	86419	86432	86445	86458	86472	86485
483.9	86498	86511	86524	86538	86551	86564	86577	86590	86604	86617
484.0	86630	86643	86656	86670	86683	86696	86709	86722	86736	86749
484.1	86764	86777	86791	86804	86818	86831	86844	86858	86871	86885
484.2	86897	86910	86924	86937	86950	86964	86977	86990	87003	87017
484.3	87031	87044	87058	87071	87085	87098	87111	87125	87138	87152
484.4	87164	87177	87191	87204	87217	87231	87244	87257	87270	87284
484.5	87298	87311	87325	87338	87352	87365	87378	87392	87405	87419
484.6	87432	87445	87459	87472	87486	87499	87512	87526	87539	87553
484.7	87565	87578	87592	87605	87618	87632	87645	87658	87671	87685
484.8	87699	87712	87726	87739	87753	87766	87779	87793	87806	87820
484.9	87832	87845	87859	87872	87885	87899	87912	87925	87938	87952
485.0	87966	87979	87993	88006	88020	88033	88046	88060	88073	88087
485.1	88101	88115	88128	88142	88155	88169	88182	88196	88209	88223
485.2	88236	88250	88263	88277	88290	88304	88317	88331	88344	88358
485.3	88371	88385	88398	88412	88425	88439	88452	88466	88479	88493
485.4	88506	88520	88533	88547	88560	88574	88587	88601	88614	88628
485.5	88642	88656	88669	88683	88696	88710	88724	88737	88751	88764
485.6	88777	88791	88804	88818	88831	88845	88858	88872	88885	88899
485.7	88912	88926	88939	88953	88966	88980	88993	89007	89020	89034
485.8	89047	89061	89074	89088	89101	89115	89128	89142	89155	89169
485.9	89182	89196	89209	89223	89236	89250	89263	89277	89290	89304
486.0	89317	89331	89344	89358	89371	89385	89398	89412	89425	89439
486.1	89454	89468	89481	89495	89509	89523	89536	89550	89564	89577
486.2	89590	89604	89617	89631	89644	89658	89672	89685	89699	89712
486.3	89727	89741	89754	89768	89782	89796	89809	89823	89837	89850
486.4	89863	89877	89890	89904	89917	89931	89945	89958	89972	89985
486.5	90000	90014	90027	90041	90055	90069	90082	90096	90110	90123
486.6	90137	90151	90164	90178	90192	90206	90219	90233	90247	90260
486.7	90273	90287	90300	90314	90327	90341	90355	90368	90382	90395
486.8	90410	90424	90437	90451	90465	90479	90492	90506	90520	90533
486.9	90546	90560	90573	90587	90600	90614	90628	90641	90655	90668
487.0	90683	90697	90710	90724	90738	90752	90765	90779	90793	90806
487.1	90821	90835	90849	90862	90876	90890	90904	90918	90931	90945
487.2	90959	90973	90987	91000	91014	91028	91042	91056	91069	91083
487.3	91098	91112	91126	91140	91154	91168	91181	91195	91209	91223
487.4	91236	91250	91264	91277	91291	91305	91319	91333	91346	91360

487.5	91374	91388	91402	91415	91429	91443	91457	91471	91484	91498
487.6	91512	91526	91540	91553	91567	91581	91595	91609	91622	91636
487.7	91650	91664	91678	91691	91705	91719	91733	91747	91760	91774
487.8	91789	91803	91817	91831	91845	91859	91872	91886	91900	91914
487.9	91927	91941	91955	91968	91982	91996	92010	92024	92037	92051
488.0	92065	92079	92093	92106	92120	92134	92148	92162	92175	92189
488.1	92205	92219	92233	92247	92261	92275	92289	92303	92317	92331
488.2	92345	92359	92373	92387	92401	92415	92429	92443	92457	92471
488.3	92485	92499	92513	92527	92541	92555	92569	92583	92597	92611
488.4	92625	92639	92653	92667	92681	92695	92709	92723	92737	92751
488.5	92764	92778	92792	92806	92820	92834	92847	92861	92875	92889
488.6	92904	92918	92932	92946	92960	92974	92988	93002	93016	93030
488.7	93044	93058	93072	93086	93100	93114	93128	93142	93156	93170
488.8	93184	93198	93212	93226	93240	93254	93268	93282	93296	93310
488.9	93324	93338	93352	93366	93380	93394	93408	93422	93436	93450
489.0	93464	93478	93492	93506	93520	93534	93548	93562	93576	93590
489.1	93605	93619	93633	93647	93661	93676	93690	93704	93718	93732
489.2	93747	93761	93775	93790	93804	93818	93832	93846	93861	93875
489.3	93888	93902	93916	93930	93944	93959	93973	93987	94001	94015
489.4	94030	94044	94058	94073	94087	94101	94115	94129	94144	94158
489.5	94171	94185	94199	94213	94227	94242	94256	94270	94284	94298
489.6	94312	94326	94340	94354	94368	94383	94397	94411	94425	94439
489.7	94454	94468	94482	94497	94511	94525	94539	94553	94568	94582
489.8	94595	94609	94623	94637	94651	94666	94680	94694	94708	94722
489.9	94737	94751	94765	94780	94794	94808	94822	94836	94851	94865
490.0	94878	94892	94906	94920	94934	94949	94963	94977	94991	95005
490.1	95021	95035	95050	95064	95078	95093	95107	95121	95135	95150
490.2	95164	95178	95193	95207	95221	95236	95250	95264	95278	95293
490.3	95307	95321	95336	95350	95364	95379	95393	95407	95421	95436
490.4	95450	95464	95479	95493	95507	95522	95536	95550	95564	95579
490.5	95593	95607	95622	95636	95650	95665	95679	95693	95707	95722
490.6	95736	95750	95765	95779	95793	95808	95822	95836	95850	95865
490.7	95879	95893	95908	95922	95936	95951	95965	95979	95993	96008
490.8	96022	96036	96051	96065	96079	96094	96108	96122	96136	96151
490.9	96165	96179	96194	96208	96222	96237	96251	96265	96279	96294
491.0	96308	96322	96337	96351	96365	96380	96394	96408	96422	96437
491.1	96453	96468	96482	96497	96511	96526	96540	96555	96569	96584
491.2	96597	96611	96626	96640	96655	96669	96683	96698	96712	96727
491.3	96742	96757	96771	96786	96800	96815	96829	96844	96858	96873
491.4	96886	96900	96915	96929	96944	96958	96972	96987	97001	97016
491.5	97031	97046	97060	97075	97089	97104	97118	97133	97147	97162
491.6	97176	97191	97205	97220	97234	97249	97263	97278	97292	97307
491.7	97320	97334	97349	97363	97378	97392	97406	97421	97435	97450
491.8	97465	97480	97494	97509	97523	97538	97552	97567	97581	97596
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492.0	97754	97769	97783	97798	97812	97827	97841	97856	97870	97885
492.1	97900	97915	97929	97944	97958	97973	97988	98002	98017	98031
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492.3	98193	98208	98222	98237	98251	98266	98281	98295	98310	98324
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492.6	98632	98647	98661	98676	98690	98705	98720	98734	98749	98763
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492.9	99071	99086	99100	99115	99130	99145	99159	99174	99189	99203
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511.4	129103	129121	129138	129156	129173	129191	129209	129226	129244	129261
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530.4	165862	165883	165904	165925	165946	165967	165988	166009	166030	166051
530.5	166072	166093	166114	166135	166156	166177	166198	166219	166240	166261
530.6	166283	166304	166325	166346	166367	166389	166410	166431	166452	166473
530.7	166494	166515	166536	166557	166578	166600	166621	166642	166663	166684
530.8	166704	166725	166746	166767	166788	166809	166830	166851	166872	166893
530.9	166914	166935	166956	166977	166998	167019	167040	167061	167082	167103
531.0	167125	167146	167167	167188	167209	167231	167252	167273	167294	167315
531.1	167337	167358	167379	167401	167422	167443	167464	167485	167507	167528
531.2	167549	167570	167591	167613	167634	167655	167676	167697	167719	167740
531.3	167761	167782	167803	167825	167846	167867	167888	167909	167931	167952
531.4	167973	167994	168015	168037	168058	168079	168100	168121	168143	168164
531.5	168185	168206	168227	168249	168270	168291	168312	168333	168355	168376
531.6	168397	168418	168439	168461	168482	168503	168524	168545	168567	168588
531.7	168609	168630	168651	168673	168694	168715	168736	168757	168779	168800
531.8	168821	168842	168863	168885	168906	168927	168948	168969	168991	169012
531.9	169033	169054	169075	169097	169118	169139	169160	169181	169203	169224
532.0	169245	169266	169287	169309	169330	169351	169372	169393	169415	169436
532.1	169459	169480	169502	169523	169545	169566	169587	169609	169630	169652
532.2	169672	169693	169715	169736	169757	169779	169800	169821	169842	169864

532.3	169886	169907	169929	169950	169972	169993	170014	170036	170057	170079
532.4	170100	170121	170143	170164	170186	170207	170228	170250	170271	170293
532.5	170314	170335	170357	170378	170400	170421	170442	170464	170485	170507
532.6	170527	170548	170570	170591	170612	170634	170655	170676	170697	170719
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532.8	170955	170976	170998	171019	171041	171062	171083	171105	171126	171148
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533.0	171382	171402	171422	171442	171462	171482	171501	171521	171541	171561
533.1	171597	171619	171640	171662	171683	171705	171726	171748	171769	171791
533.2	171813	171835	171856	171878	171899	171921	171943	171964	171986	172007
533.3	172028	172050	172071	172093	172114	172136	172157	172179	172200	172222
533.4	172244	172266	172287	172309	172330	172352	172374	172395	172417	172438
533.5	172459	172481	172502	172524	172545	172567	172588	172610	172631	172653
533.6	172674	172696	172717	172739	172760	172782	172803	172825	172846	172868
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533.9	173321	173343	173364	173386	173407	173429	173451	173472	173494	173515
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534.2	173970	173992	174013	174035	174057	174079	174100	174122	174144	174165
534.3	174187	174209	174230	174252	174274	174296	174317	174339	174361	174382
534.4	174404	174426	174447	174469	174491	174513	174534	174556	174578	174599
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534.8	175272	175294	175315	175337	175359	175381	175402	175424	175446	175467
534.9	175489	175511	175532	175554	175576	175598	175619	175641	175663	175684
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535.2	176143	176165	176187	176208	176230	176252	176274	176296	176317	176339
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536.4	178774	178796	178818	178840	178862	178884	178906	178928	178950	178972
536.5	178994	179016	179038	179060	179082	179104	179126	179148	179170	179192
536.6	179215	179237	179259	179281	179303	179326	179348	179370	179392	179414
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537.3	180762	180784	180806	180829	180851	180873	180895	180917	180940	180962
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541.1	189303	189326	189349	189372	189395	189418	189440	189463	189486	189509
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541.5	190218	190241	190264	190287	190310	190333	190355	190378	190401	190424
541.6	190446	190469	190492	190514	190537	190560	190583	190606	190628	190651
541.7	190675	190698	190721	190744	190767	190790	190812	190835	190858	190881
541.8	190904	190927	190950	190973	190996	191019	191041	191064	191087	191110
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544.3	196685	196708	196732	196755	196779	196802	196825	196849	196872	196896
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547.5	204240	204264	204288	204312	204336	204360	204383	204407	204431	204455
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570.2	262762	262790	262817	262845	262873	262901	262928	262956	262984	263011
570.3	263039	263067	263094	263122	263150	263178	263205	263233	263261	263288
570.4	263316	263344	263371	263399	263427	263455	263482	263510	263538	263565
570.5	263593	263621	263648	263676	263704	263732	263759	263787	263815	263842
570.6	263870	263898	263925	263953	263981	264009	264036	264064	264092	264119
570.7	264147	264175	264202	264230	264258	264286	264313	264341	264369	264396
570.8	264424	264452	264479	264507	264535	264563	264590	264618	264646	264673
570.9	264701	264729	264756	264784	264812	264840	264867	264895	264923	264950
571.0	264978	265006	265033	265061	265089	265117	265144	265172	265200	265227
571.1	265257	265285	265313	265341	265369	265397	265424	265452	265480	265508
571.2	265536	265564	265592	265620	265648	265676	265703	265731	265759	265787
571.3	265814	265842	265870	265897	265925	265953	265981	266009	266036	266064
571.4	266093	266121	266149	266177	266205	266233	266260	266288	266316	266344

571.5	266372	266400	266428	266456	266484	266512	266539	266567	266595	266623
571.6	266651	266679	266707	266735	266763	266791	266818	266846	266874	266902
571.7	266930	266958	266986	267014	267042	267070	267097	267125	267153	267181
571.8	267208	267236	267264	267291	267319	267347	267375	267403	267430	267458
571.9	267487	267515	267543	267571	267599	267627	267654	267682	267710	267738
572.0	267766	267794	267822	267850	267878	267906	267933	267961	267989	268017
572.1	268047	268075	268103	268131	268159	268188	268216	268244	268272	268300
572.2	268327	268355	268383	268411	268439	268467	268495	268523	268551	268579
572.3	268608	268636	268664	268692	268720	268749	268777	268805	268833	268861
572.4	268888	268916	268944	268972	269000	269028	269056	269084	269112	269140
572.5	269169	269197	269225	269253	269281	269310	269338	269366	269394	269422
572.6	269450	269478	269506	269534	269562	269591	269619	269647	269675	269703
572.7	269730	269758	269786	269814	269842	269870	269898	269926	269954	269982
572.8	270011	270039	270067	270095	270123	270152	270180	270208	270236	270264
572.9	270291	270319	270347	270375	270403	270431	270459	270487	270515	270543
573.0	270572	270600	270628	270656	270684	270713	270741	270769	270797	270825
573.1	270854	270882	270910	270939	270967	270995	271023	271051	271080	271108
573.2	271136	271164	271192	271221	271249	271277	271305	271333	271362	271390
573.3	271419	271447	271476	271504	271532	271561	271589	271617	271645	271674
573.4	271701	271729	271757	271786	271814	271842	271870	271898	271927	271955
573.5	271983	272011	272039	272068	272096	272124	272152	272180	272209	272237
573.6	272265	272293	272321	272350	272378	272406	272434	272462	272491	272519
573.7	272547	272575	272603	272632	272660	272688	272716	272744	272773	272801
573.8	272830	272858	272887	272915	272943	272972	273000	273028	273056	273085
573.9	273112	273140	273168	273197	273225	273253	273281	273309	273338	273366
574.0	273394	273422	273450	273479	273507	273535	273563	273591	273620	273648
574.1	273678	273706	273735	273763	273792	273820	273848	273877	273905	273934
574.2	273962	273990	274019	274047	274076	274104	274132	274161	274189	274218
574.3	274246	274274	274303	274331	274360	274388	274416	274445	274473	274502
574.4	274530	274558	274587	274615	274644	274672	274700	274729	274757	274786
574.5	274814	274842	274871	274899	274928	274956	274984	275013	275041	275070
574.6	275098	275126	275155	275183	275212	275240	275268	275297	275325	275354
574.7	275382	275410	275439	275467	275496	275524	275552	275581	275609	275638
574.8	275666	275694	275723	275751	275780	275808	275836	275865	275893	275922
574.9	275950	275978	276007	276035	276064	276092	276120	276149	276177	276206
575.0	276234	276262	276291	276319	276348	276376	276404	276433	276461	276490
575.1	276520	276549	276577	276606	276634	276663	276692	276720	276749	276777
575.2	276806	276835	276863	276892	276920	276949	276978	277006	277035	277063
575.3	277091	277120	277148	277177	277205	277234	277262	277291	277319	277348
575.4	277377	277406	277434	277463	277491	277520	277549	277577	277606	277634
575.5	277663	277692	277720	277749	277777	277806	277835	277863	277892	277920
575.6	277949	277978	278006	278035	278063	278092	278121	278149	278178	278206
575.7	278235	278264	278292	278321	278349	278378	278407	278435	278464	278492
575.8	278520	278549	278577	278606	278634	278663	278691	278720	278748	278777
575.9	278806	278835	278863	278892	278920	278949	278978	279006	279035	279063
576.0	279092	279121	279149	279178	279206	279235	279264	279292	279321	279349
576.1	279379	279408	279436	279465	279494	279523	279551	279580	279609	279637
576.2	279677	279707	279737	279766	279796	279826	279856	279886	279915	279945
576.3	279954	279982	280009	280037	280065	280093	280120	280148	280176	280203
576.4	280242	280271	280300	280328	280357	280386	280415	280444	280472	280501
576.5	280529	280558	280586	280615	280644	280673	280701	280730	280759	280787
576.6	280816	280845	280873	280902	280931	280960	280988	281017	281046	281074
576.7	281104	281133	281162	281190	281219	281248	281277	281306	281334	281363
576.8	281391	281420	281448	281477	281506	281535	281563	281592	281621	281649
576.9	281679	281708	281737	281765	281794	281823	281852	281881	281909	281938
577.0	281966	281995	282023	282052	282081	282110	282138	282167	282196	282224

577.1	282255	282284	282313	282342	282371	282400	282428	282457	282486	282515
577.2	282544	282573	282602	282631	282660	282689	282717	282746	282775	282804
577.3	282834	282863	282892	282921	282950	282979	283008	283037	283066	283095
577.4	283133	283163	283193	283223	283253	283283	283312	283342	283372	283402
577.5	283412	283440	283468	283496	283524	283552	283579	283607	283635	283663
577.6	283701	283730	283759	283788	283817	283846	283874	283903	283932	283961
577.7	283990	284019	284048	284077	284106	284135	284163	284192	284221	284250
577.8	284280	284309	284338	284367	284396	284425	284454	284483	284512	284541
577.9	284569	284598	284627	284656	284685	284714	284742	284771	284800	284829
578.0	284858	284887	284916	284945	284974	285003	285031	285060	285089	285118
578.1	285149	285178	285207	285236	285265	285295	285324	285353	285382	285411
578.2	285440	285469	285498	285527	285556	285586	285615	285644	285673	285702
578.3	285731	285760	285789	285818	285847	285877	285906	285935	285964	285993
578.4	286022	286051	286080	286109	286138	286168	286197	286226	286255	286284
578.5	286312	286341	286370	286399	286428	286457	286486	286515	286544	286573
578.6	286603	286632	286661	286690	286719	286749	286778	286807	286836	286865
578.7	286894	286923	286952	286981	287010	287040	287069	287098	287127	287156
578.8	287185	287214	287243	287272	287301	287331	287360	287389	287418	287447
578.9	287476	287505	287534	287563	287592	287622	287651	287680	287709	287738
579.0	287767	287796	287825	287854	287883	287913	287942	287971	288000	288029
579.1	288060	288089	288119	288148	288177	288207	288236	288265	288294	288324
579.2	288352	288381	288410	288440	288469	288498	288527	288556	288586	288615
579.3	288645	288674	288704	288733	288762	288792	288821	288850	288879	288909
579.4	288937	288966	288995	289025	289054	289083	289112	289141	289171	289200
579.5	289230	289259	289289	289318	289347	289377	289406	289435	289464	289494
579.6	289523	289552	289582	289611	289640	289670	289699	289728	289757	289787
579.7	289815	289844	289873	289903	289932	289961	289990	290019	290049	290078
579.8	290108	290137	290167	290196	290225	290255	290284	290313	290342	290372
579.9	290400	290429	290458	290488	290517	290546	290575	290604	290634	290663
580.0	290693	290722	290752	290781	290810	290840	290869	290898	290927	290957

SPECIFICATIONS
Excerpts from Part B - General Conditions

1. Definitions.

(a) Whenever the words defined in this article occur in these Specifications, or in any other contract document, they shall have the meaning here defined:

(b) The word "specifications" shall include these General Conditions, the Special Conditions and the applicable portions of the Standard Specifications. The form of these Specifications is intended to provide for all of the work performed for Casitas Municipal Water District.

(c) The word "District" shall mean the Casitas Municipal Water District.

(d) The word "Board" shall mean the Board of Directors of the Casitas Municipal Water District.

(e) The words "General Manager" shall mean the person holding the position or acting in the capacity of General Manager of the Casitas Municipal Water District.

(f) The word "Engineer" shall mean the General Manager, or his duly authorized representative.

(g) The word "Contractor" shall mean the Contractor in the agreement for the construction of the work and/or the furnishing of materials and/or equipment herein specified, the legal representative, or the agent of said party.

(h) The word "Subcontractor" shall mean one who, as a subcontractor, performs at the site of the work some part of the Contractor's obligation, the legal representative, or the agent therefor.

(i) The words "Standard Specifications" shall mean the provisions of the latest edition of the Standard Specifications for Public Works Construction (SSPWC) with all supplements, prepared and promulgated by the Southern California Chapters of the American Public Works Associated and Associated General Contractors of America. Part one of the SSPWC is hereby deleted.

4. Indemnification of District. Contractor shall indemnify and hold harmless and defend United States Bureau of Reclamation, the District, their directors, employees, agents or volunteers, and each of them from and against:

(a) Any and all claims, demands, causes of action, damages, costs, expenses, losses or liabilities, in law or in equity, of every kind and nature whatsoever for, but not limited to, injury to or death of any person including District and/or Contractor, or any directors, officers, employees, agents or volunteers of District or Contractor, and damages to or destruction of property of any person, including but not limited to, District and/or Contractor and their directors, officers, employees, agents or volunteers, arising out of or in any manner directly or indirectly connected with the work to be performed under this agreement, however caused, regardless of any negligence of District or its directors, officers, employees, agents or volunteers, except the sole negligence or willful misconduct or active negligence of District or its directors, officers, employees, agents or volunteers.

(b) Any and all actions, proceedings, damages, costs expenses, penalties or liabilities, in law or equity, of every kind or nature whatsoever, arising out of resulting from, or on account of the violation of any governmental law or regulation, compliance with which is the responsibility of Contractor.

Contractor shall defend, at Contractor's own cost, expense and risk, any and all such aforesaid suits, actions or other legal proceedings of every kind that may be brought or instituted against District or District's directors, officers, employees, agents or volunteers.

Contractor shall pay and satisfy any judgment, award or decree that may be rendered against District or its directors, officers, employees, agents or volunteers, in any such suit, action or other legal proceeding.

Contractor shall reimburse District and its directors, officers, employees, agents and/or volunteers, for any and all legal expenses and costs incurred by each of them in connection therewith or in enforcing the indemnity herein provided.

Contractor agrees to carry insurance for this purpose as set out in the specifications.

5. Insurance.

(A) Contractor shall provide and maintain the following commercial general liability and automobile liability insurance:

(1) Coverage for commercial general liability and automobile liability insurance shall be at least as broad as the following:

a. Insurance Services Office Commercial General Liability coverage (Occurrence Form CG 0001).

b. Insurance Services Office Form Number CA 0001 (ed. 1/87) covering Automobile Liability, Code 1 (any auto).

(2) The Contractor shall maintain limits no less than the following:

a. General Liability. One million dollars ($1,000,000) per occurrence for bodily injury, personal injury and property damage. If Commercial General Liability Insurance or other form with a general aggregate limit is used, either the general aggregate limit shall apply separately to the project/location (with the ISO CG 2501 or insurers equivalent endorsement provided to the district) or the general aggregate limit shall be twice the required occurrence limit.

b. Automobile Liability. One million dollars ($1,000,000 per accident for bodily injury and property damage combine single limit.

(3) The general liability and automobile liability policies are to contain, or be endorsed to contain the following provisions:

a. The United States Bureau of Reclamation, Casitas Municipal Water District, their directors, officers, employees, agents and volunteers are to be covered as insureds as respects: liability arising out of activities performed by or on behalf of the Contractors, products and

completed operations of the Contractor; premises owned, occupied or used by the Contractor; or automobiles owned, leased, hired or borrowed by the Contractor. The coverage shall contain no special limitations on the scope of protection afforded to the United States Bureau of Reclamation, Casitas Municipal Water District, their directors, officers, employees, agents and volunteers.

b. For any claims related to this project, the Contractor's insurance shall be primary insurance as respects the United States Bureau of Reclamation, Casitas Municipal Water District, their directors, officers, employees, agents and volunteers. Any insurance or self-insurance maintained by the District, its directors, officers, employees, agents and volunteers shall be excess of the Contractor's insurance and shall not contribute with it.

c. Any failure to comply with reporting or other provisions of the policies including breaches of warrantees shall not affect coverage provided to the United States Bureau of Reclamation, Casitas Municipal Water District, their directors, officers, employees, agents and volunteers.

d. The Contractor's insurance shall apply separately to each insured against whom claim is made or suit is brought, except with respect to the limits of the insurer's liability.

e. Each insurance policy required by this clause shall be endorsed to state that coverage shall not be suspended, voided, canceled by either party, reduced in coverage or in limits except after thirty (30) days prior to written notice by certified mail, return receipt requested, has been given to the District.

f. Such liability insurance shall indemnify the Contractor and his subcontractors against loss from liability imposed by law upon, or assumed under contract by, the Contractor or his subcontractors for damages on account of such bodily injury (including death), property damage, personal injury and completed operations and products liability. Such insurance shall be provided on a policy written by underwriters through an agency satisfactory to the District (see Section 4-08.05), which includes a cross-liability clause, and covers bodily injury and property damage liability, owned and non-owned vehicles and equipment, blanket contractual liability and completed operations liability. Such liability insurance shall include explosion, collapse, underground excavation and removal of lateral support. The United States Bureau of Reclamation, Casitas Municipal Water District, their directors, officers, employees agents and volunteers shall be named as additional primary insured on any such policies. An additional insured endorsement (ISO CG 2010 or equivalent) (modified to include provisions 2-5 above) and a certificate of insurance (Accord Form 25-S or equivalent), shall be provided to the District.

(4) Any deductible or self-insured retention must be declared to and approved by the District. At the option of the District, either the insurer shall reduce or eliminate such deductibles or self-insured retentions as respects the District, its directors, officers, employees, agents and volunteers; or the Contractor shall procure a bond guaranteeing payment of losses and related investigations, claim administration and defense expenses.

(5) Insurance is to be placed with insurers having a current A.M. Best's rating of no less than A:VII or equivalent.

(6) The Contractor shall not commence work under this contract, nor allow any subcontractor to commence work on this subcontract, until he has secured all insurance required under the section and has filed with the District, certificates of insurance in the amounts specified. Such certificates shall contain a provision that they may not be called without at least thirty (30) days' written notice to the District.

(B) **Worker's Compensation Insurance**.

(1) By his signature hereunder, Contractor certifies that he is aware of the provisions of Section 3700 of the Labor Code which require every employer to be insured against liability for worker's compensation or to undertake self-insurance in accordance with the provisions of that code, and he will comply with such provisions before commencing the performance of the work of this contract.

(2) The Contractor shall maintain, and shall cause all subcontractors he may employ to maintain adequate workers compensation insurance under the laws of the State of California for all labor employed by them, directly or indirectly, in the execution of the work. The Contractor and all subcontractors shall file with the District certification of such workers compensation insurance prior to beginning construction.

(C) **Evidences and Cancellation of Insurance**.

(1) Prior to execution of the contract, the Contractor shall file with the District evidence of insurance from an insurer or insurers certifying to the coverage of all insurance required herein. Such evidence shall include the ISO CG 2010 (or insurer's equivalent) signed by the insurer's representative and certificate of insurance (Accord Form 25-S or equivalent). All evidence of insurance shall be certified by a properly authorized officer, agent or qualified representative of the insurer and shall certify the names of the insured, any additional primary insurers, where appropriate, the type and amount of the insurance, the location and operations to which the insurance applies, the expiration date, and that the insurer will give by certified mail, written notice to the District at least thirty (30) days prior to the effective date of any cancellation, lapse or material change in the policy.

(2) The Contractor shall, upon demand of the District, deliver to the District all such policy or policies of insurance and the receipts for payment or premiums thereon; and should the Contractor neglect to obtain and maintain in force any such insurance or deliver such policy or policies and receipts to the District, then is shall be lawful for the District to obtain and maintain such insurance, and the Contractor hereby appoints the District his true and lawful attorney-in-fact to do all things necessary for this purpose. All money paid by the District for insurance premiums under the provisions of this article shall be charged to the Contractor.

CASITAS MUNICIPAL WATER DISTRICT
SUMMARY OF INSURANCE, BOND & PAYMENT REQUIREMENTS
FOR VARIOUS CONSTRUCTION CONTRACTS

	Informal Under $35,000	**Formal** $35,000 & Over
Certificates of Insurance (CG 2010 Endorsement required))		
1. Workmen's Compensation	Yes	Yes
2. Commercial, General & Auto Liability	Yes	Yes
a. For one person per accident	$1,000,000	$1,000,000
b. More than one person per accident	$1,000,000	$1,000,000
3. Property damage per accident	$1,000,000	$1,000,000
4. Thirty days written notice prior to cancellation	Yes	Yes
Bonds		
Bidder's Bonds	None	10%
Payment Bonds (Material and Labor)* (Projects bid by CMWD only)	None	100%
Performance Bonds* (Projects bid by CMWD only)	None	100%
Maintenance and Guarantee Provisions	Yes	Yes
Contracts		
Period for Final payment upon acceptance	15 Days	35 Days
Amount of Retention	0, or stated in specs	10%
Progress Payment (if required, retain 5%)**	Per specs	Per specs
Final Cost Statement	None	Yes
Notice of Completion	None	Yes
Labor and Material Releases	Yes	Yes

* At the option of the District and depending upon the type of construction activity, payment bonds and/or performance bonds may be placed as a requirement on the job.

** If progress payments are required for a Purchase Order Contract, provisions therefor must be added.

NOTE:

The above listed are the minimum requirements for all construction contracts. Provisions are included within the Terms and Conditions for Purchase Order Contracts which will be issued for all jobs under $35,000 and provisions should be included within the Specifications for all contracts which are $35,000 and over. **The U.S. Bureau of Reclamation, Casitas Municipal Water District, their directors, officers, employees or authorized volunteers shall be named as additional insured as respects to all coverages listed above when the named insured is Lessee or Licensee of the Casitas Municipal Water District or when work is performed by the named insured for the Casitas Municipal Water District, and in both instances this coverage shall be primary.** Casitas, in addition to Certificates of Insurance, shall be provided with the ISO CG 2510 Endorsement or insurer′s equivalent.

Boat Access Restrictions at Lake Casitas
To Prevent Invasive Species Contamination

Pursuant to Ordinance 16-01, restrictions have been imposed on vessels entering the Lake Casitas Recreation Area, including canoes and kayaks. **FLOAT TUBES ARE NOT ALLOWED.**

Customers may participate in a Tamper Proof Tag Program. Vessels that pass inspection must complete a 35-Day Quarantine period either inside or outside the Recreation Area. Please read our Policies & Procedures for Vessel Inspections and the Tamper Proof Tag Program below.

For questions, information **and to make an inspection appointment**, please call (805)-649-2233.

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CASITAS MUNICIPAL WATER DISTRICT
POLICIES & PROCEDURES FOR VESSEL INSPECTION FOR QUAGGA MUSSELS
LAKE CASITAS RECREATION AREA

1. Policies & Procedures

The policies and procedures in this document are for inspection criteria for vessels entering the Lake Casitas Recreation Area. These policies and procedures are to ensure that invasive species do not enter Lake Casitas and impact treatment infrastructure and threaten the lake's ecosystem.

In order to be consistent with policies, procedures and training, the Lake Casitas Recreation Area Vessel Inspection Checklist will be used on all vessel inspections. This document outlines the process that staff must complete before a vessel of any kind is authorized to enter the Lake Casitas Recreation Area. The Vessel Inspection Checklist is a check off sheet outlining aspects of this policies and procedures document. Each step in the Vessel Inspection Checklist has specific expectations associated with it and will only be conducted by fully trained staff.

Lake Casitas Recreation Area staff will follow a zero tolerance policy for inspection criteria. If at anytime during an inspection a vessel fails a step on the Vessel Inspection Checklist, the vessel will fail the inspection process and a re-inspection will need to be scheduled. The re-inspection will be scheduled no sooner than seven (7) days, i.e. the same weekday of the following calendar week. Upon passing a re-inspection, the vessel will be quarantined for thirty-five (35) days.

At the discretion of Casitas Municipal Water District, vessels may be subject to random bilge water test that will examine water microscopically.

Vessel Inspection Checklist

(a) The owner/operator is to be informed that an inspection will be performed and that Casitas has a zero tolerance policy for any water, including condensation, debris, or growth found on any vessel, trailer or towing vehicle due to possible transportation of invasive species by vessels and trailers.

(b) Staff will write the state boating identification number and owner/operator's name and date on the Vessel Inspection Checklist.

(c) Staff will check the Casitas generated database of vessels that have previously been denied access due to inspection issues. A re-inspection cannot be performed until the due date.

(d) Customer will fill out and sign the "Vessel Quarantine, Re-Entry, Temporary Storage and Tamper-Proof Tag Acknowledgement" (Acknowledgement) in staff's presence. Customer is voluntarily signing the Vessel Acknowledgement under penalty of perjury. After the customer signs the Vessel Acknowledgement, he/she will be given the bottom yellow carbon copy of the Vessel Acknowledgement.

(e) Staff has been directed to provide educational materials to the boating community and general public. Two handouts are given to each vessel operator/owner upon first entry to the park and in general as new information becomes available as follows:

(1) Casitas flyer entitled "Take Action to Save Our Lakes from Quagga Mussels".
(2) Department of Fish & Wildlife flyer entitled "Don't Move A Mussel".

(f) Staff will request the owner/operator of the vessel to open all compartments.

(g) The vessel, trailer and vehicle inspection will include looking for moisture, water, debris including but not limited to: mud, weeds, sand/pebbles or growth on or in any inspected area. Surfaces will also be touched to see if growth or mussels may be attached. The inspection will be completed the same way each time starting at one side of the vehicle, vessel and trailer and ending at the other side. Checking the "Yes" box indicates that the inspected material is dry and clear of debris. If the "No" box is checked the vessel has failed, will be placed on the Casitas 7-day wait list and will not be eligible for re-inspection for seven (7) days.

2. **Areas of Inspection**

The following areas will be inspected by Staff:

(a) **Vehicle Rear**: The vehicle bumper, tailgate or spare tire may have mud, grass, weeds or other debris on it. If there are positive signs of mud, etc., the inspection cannot continue. The vessel may return at a later date for re-inspection, towed by a different vehicle.

(b) **Trailer Structure, Railings and Spare Tire**: The trailer, railings and spare tire may have mud, grass, weeds, debris or standing water. If there are positive signs of mud, etc., the inspection cannot continue. The vessel may return at a later date for re-inspection or on a different trailer that is clean and dry.

(c) **Vessel Hull**: The vessel hull will be inspected for growth and debris. Growth may be visible if ~~it~~ the vessel has been in the water for an extended period of time. Small mussels attached to a vessel can feel like sandpaper or sesame seeds. If a vessel's hull has any type of growth or debris, the vessel will not be eligible for re-inspection for a minimum of seven (7) days and will be placed on the Casitas 7-day wait list.

(d) **Transom**: The transom is at the back of the vessel where the engine is attached. The transom may have several items of importance for inspection that mussels can attach to including the out drive, trim tabs, transducers, bilge plug area and through hull fittings. The transom must be checked to make sure the surface is smooth and visibly clear of all debris and growth. If there are positive signs of growth, etc. the vessel will not be eligible for re-inspection for a minimum of seven (7) days and will be placed on the Casitas 7-day wait list.

(e) **Outdrive**: The outdrive is attached to the transom on stern drive vessels and the lower unit on outboard vessels. It has intricate parts that make it easy for mussels to attach, hide and grow. Staff will feel and look for any signs of growth, debris or texture of sandpaper. If there are positive signs of growth, debris or texture of sandpaper, etc. the vessel will not be eligible for re-inspection for a minimum of seven

(7) days and will be placed on the Casitas 7-day wait list.

(f) **Propeller/Shafts**: Mussels can attach and live on or around where the propeller attaches to the lower unit of the drive shaft. Mussels can also attach to the shaft or connecting points of the vessel. These can be hard to see and must be inspected with a flashlight to verify if any mussels, debris or water are present. If there are positive signs of mussels, etc. the vessel will not be eligible for re-inspection for a minimum of seven (7) days and will be placed on the Casitas 7-day wait list.

(g) **Trim Tabs**: Trim tabs are located on the lower portion of the transom and are usually metal plates that help stabilize the vessel while underway. Staff will feel the corners, edges and look on the underside of the trim tabs for debris and growth. If there are positive signs of growth, etc. the vessel will not be eligible for re-inspection for a minimum of seven (7) days and will be placed on the Casitas 7-day wait list.

(h) **Transducers:** These are located on the transom or bottom of the hull near the stern of the vessel. They are used in conjunction with a computer to determine depth, speed and water temperature. Growth or debris can appear on them. If there are positive signs of growth, etc. the vessel will not be eligible for re-inspection for a minimum of seven (7) days and will be placed on the Casitas 7-day wait list.

(i) **Bilge Plug**: If the bilge plug is pulled when the vessel arrives at the lake, there should be no fluid or debris coming from it. Staff will carefully insert fingers in the plug hole to determine if debris is blocking water from exiting. If the bilge plug is not pulled, the owner/operator will be requested to pull the plug. If water exits, the plug will be reinstalled to prevent additional water from being released. If there are positive signs of growth, etc. the vessel will not be eligible for re-inspection for a minimum of seven (7) days and will be placed on the Casitas 7-day wait list.

(j) **Through Hull Fittings**: Through hull fitting in all boats have the potential to store mussels in the right conditions. To check these fittings, Staff will use a flashlight to look inside and feel for irregularities. If water or debris is observed or felt, the vessel will be eligible for re-inspection for a minimum of seven (7) days and will be placed on the Casitas 7-day wait list.

(k) **Bait Tank/Live Well/Compartments**: Bait tanks, live wells and compartments should be dry and clear of all water and debris. Some compartments do not drain completely due to the way they are manufactured. Any debris in compartments is not acceptable. Common debris often found includes; fish scales, weeds, small pebbles and trash. If it does have positive signs of fish, etc., the vessel will not be eligible for re-inspection for a minimum of seven (7) days and will be placed on the Casitas 7-day wait list.

(l) **Bilge**: The bilge is at the bottom of the inside stern of the vessel. It may not be visible in all boats due to various boat designs. The bilge should be clean from all water and debris. If there are positive signs of water, etc. the vessel will not be eligible for re-inspection for a minimum of seven (7) days and will be placed on the Casitas 7-day wait list.

(m) **Anchor/Fenders and Line**: Anchors can have mud or debris on them. If an anchor, fender and lines attached have been in infested water for an extended period of time then mussels and debris can attach. Staff must check these items for mud, growth and debris. If there are positive signs of mud, etc. the vessel will not be eligible for re-inspection for a minimum of seven (7) days and will be placed on the Casitas 7-day wait list.

(n) **Trolling Motor**: Trolling motors can pick up plants and debris while being used and must be inspected. These items must be checked for mud, growth and debris. If there are positive signs of mud, etc.,

the vessel will not be eligible for re-inspection for a minimum of seven (7) days and will be placed on the Casitas 7-day wait list.

The Vessel Inspection Procedures, Vessel Inspection Checklist, Vessel Acknowledgement and Casitas handouts have been developed to ensure proper inspections of vessels, trailers and vehicles to prevent Lake Casitas from becoming infested with invasive species. All documents pertaining to the Vessel Inspection Procedures are subject to change due to updated policies at the sole discretion of the District.

****

Scroll down to see Checklist &
Quarantine & Tamper Proof Tag Program

Date: _____

LAKE CASITAS RECREATION AREA - VESSEL INSPECTION CHECKLIST

CF #: _____ Owner/Operator (Print Name) _____

☐ Computer check to see if vessel has been previously denied entry.

☐ Completed Vessel Acknowledgement. Have owner/operator complete and sign form.

☐ Informational handouts "Take Action to Save Our Lakes" and "Don't Move a Mussel" flyers given.

☐ Request vessel owner to open all compartments and have the bilge plug pulled.

☐ Inform owner/operator that Casitas has a no tolerance policy for any water, debris or growth found on any vessel due to possible transportation of invasive species by vessels and trailers.

Vessel Inspection: Check for **WATER, DEBRIS** or **GROWTH** and check all smooth surfaces for **"SANDPAPER"** feel.

Clear of Water, Debris and/or Growth: Check appropriate box below.

Yes	**No**	
☐	☐	Vehicle rear
☐	☐	Trailer structure, railings, spare tire
☐	☐	Vessel hull
☐	☐	Transom
☐	☐	Outdrive
☐	☐	Prop/shafts (propeller on the engine)
☐	☐	Trim tabs (located on back of hull near engine. Not all vessels have them)
☐	☐	Transducers
☐	☐	Bilge plug pulled – no fluid or debris
☐	☐	Through hull fittings
☐	☐	Bait tank/live wells/compartments
☐	☐	Bilge (may not be visible)
☐	☐	Anchor/fenders and line
☐	☐	Trolling Motor

☐ Your vessel has not cleared the inspection due to water and or debris in one or more areas. A re-inspection will need to be scheduled with staff. The re-inspection will be scheduled no sooner than seven (7) days, meaning the same weekday of today's date next calendar week. This zero tolerance has been established to ensure the safety of Lake Casitas water quality and its ecosystem. Thank you for understanding in this matter.

☐ You may enter the Lake Casitas Recreation Area on the date indicated on the Vessel Acknowledgement. Thank you for your cooperation.

_____ _____

Date Staff (PRINT NAME)

CASITAS MUNICIPAL WATER DISTRICT
LAKE CASITAS RECREATION AREA
VESSEL QUARANTINE, RE-ENTRY, TEMPORARY STORAGE AND TAMPER-PROOF TAG PROGRAMS

THESE PROGRAMS ARE NOT AVAILABLE FOR SKI BOATS WITH INTERNAL BLADDERS OR FLOAT TUBES.

Programs have been developed for quarantine procedures, tamper-proof cables and tags and provision for limited temporary storage.

A. INSPECTION

1. Vessel inspections are available by appointment only.

2. An inspection will be conducted by authorized staff only in accordance with the attached policy entitled "Policies & Procedures for Vessel Inspection for Quagga Mussels". If the vessel passes inspection it will continue with the thirty-five (35) day Quarantine process described in B below. If the vessel does not pass, the customer's name and vessel state issued identification numbers will be placed on the 7-day wait list. The vessel will not be eligible for re-inspection for a minimum of seven (7) days, i.e. the same weekday of the following calendar week.

3. At the discretion of Casitas Municipal Water District, vessels may be subject to random bilge water testing that will examine the water microscopically.

B. 35-DAY QUARANTINE PROCESS

1. If the customer has been assigned a dry storage space (Trailer Storage Area):

   (a) Verify that the vessel has a current annual boat permit.
   (b) Place a customer or Casitas owned cable on the vessel with a Casitas tag.
   (c) Enter release date in log book.
   (d) Escort the customer to his/her assigned space.
   (e) Place tongue lock or cuff over the tongue of the trailer.
   (d) Advise customer to retain a copy of the Checklist and Vessel Acknowledgement containing the quarantine expiration date.

2. If the customer has an assigned Boat Rental slip:

   (a) Verify that the vessel has a current annual boat permit.
   (b) Place a customer or Casitas owned cable on the vessel with a Casitas tag.
   (c) Enter release date in log book.
   (d) Escort the customer to his/her assigned space.
   (e) Place tongue lock or cuff over the tongue of the trailer.
   (d) Advise customer to retain a copy of the Checklist and Vessel Acknowledgement containing the quarantine expiration date.

3. If the customer is participating in the Tamper-Proof Tag Program and is completing the thirty-five (35) day Quarantine period inside the park:

(a) Direct the customer's attention to the disclaimer for temporary quarantine parking on the signed Vessel Acknowledgement.
(b) Place a customer or Casitas owned cable on the vessel with a Casitas tag.
(c) Enter release date in log book.
(d) Escort the customer to the designated space.
(e) Place tongue lock or cuff over the tongue of the trailer.
(f) Advise customer to retain a copy of the Checklist and Vessel Acknowledgement containing the quarantine expiration date.

4. If the customer **declines** to participate in the Tamper-Proof Tag Program and is completing the thirty-five (35) day Quarantine period inside the park:

(a) Direct the customer's attention to the disclaimer for temporary quarantine parking on the signed Vessel Acknowledgement.
(b) Place a Casitas owned cable on the vessel with a Casitas tag.
(c) Enter release date in log book.
(d) Escort the customer to the designated space.
(e) Place tongue lock or cuff over the tongue of the trailer.
(f) Advise customer to retain a copy of the Checklist and Vessel Acknowledgement containing the quarantine expiration date.
(g) Upon completion of the thirty-five (35) day quarantine collect applicable fees (e.g. day use or overnight boat, etc.).

5. The customer may complete the thirty-five (35) day Quarantine Process outside the park by participating in the applicable sections of the Tamper-Proof Tag Program described in B below.

6. At the end of the quarantine period, staff will remove the lock or cuff. It is the responsibility of customers to immediately remove their vessels from the quarantine area. Any vessel left in the quarantine area longer than fifteen (15) days after release of the tongue lock or cuff will be removed by Casitas and stored at the owner's sole cost and expense.

B. TAMPER-PROOF TAG PROGRAM

The purpose of this policy and procedure is to guarantee that vessels entering and leaving periodically have not been in any infected waters. This will be accomplished by installing a tamper-proof cable, padlock, and a tamper-proof security tag. The tamper-proof cable must be attached to both the vessel and the trailer. The connection points must be in a location that prevents a part of the vessel or trailer from being removed without damaging the cable or tamper-proof security tag.

1. All vessels are subject to a thirty-five (35) day Quarantine period which may be completed inside or outside the park.

2. Customers must schedule appointments with authorized staff.

3. Inspections will be conducted by authorized staff only in accordance with the inspection policy.

(a) If the vessel passes inspection it will continue with the Tamper-Proof Tag Program process. The customer will be advised to retain a copy of the Checklist and Vessel Acknowledgement containing the quarantine expiration date.

(b) If the vessel does not pass, the customer's name and vessel identification number will be placed on the Casitas 7-day wait list. The vessel will not be eligible for re-inspection for a minimum of seven (7) days i.e. the same weekday of the following calendar week.

4. For Vessels Completing the Thirty-Five (35) day Quarantine Period Outside the Park

(a) The vessel owner/operator will be informed that a security kit must be purchased consisting of a weatherproof tamper-proof steel cable, weather resistant padlock and a tamper-proof tag. The connection point areas must be reviewed with the vessel owner/operator with an explanation as to why these locations have been chosen.

(b) The vessel owner/operator shall install the equipment as needed. The connection points must be verified and relocated by the owner/operator if necessary.

(c) The tamper-proof security seal must be installed as required and the Tamper Proof Tag Program Log updated. The vessel owner/operator must verify the tamper-proof security number and cable number and sign the Tamper Proof Tag Program Log. The vessel owner/operator must be informed that if the weatherproof tamper-proof steel cable and tamper-proof security tag are not in place or damaged in any way upon his/her return, a new inspection and thirty-five (35) day Quarantine period will be required.

(d) The vessel owner/operator must be informed that the vessel has been placed on a thirty-five (35) day Quarantine list and that he/she may leave the park and return after the thirty-five (35) day Quarantine period has been completed.

(e) Vessels returning to the park after completing the Tamper-Proof Tag Program will have the weatherproof tamper-proof steel cable and tamper-proof security tag inspected by Staff and the cable and tag numbers verified with the entries in the Log. As long as the tamper-proof security cable and tag are not missing or damaged, the tamper-proof security tag will be removed by Staff and the vessel will be allowed to enter the park and launch. **Special Note:** A "Clean & Dry Inspection" will not be required because the vessel and trailer will not have been in any other body of water.

(f) If there is **any** evidence that the weatherproof tamper-proof steel cable and/or tamper-proof security tag have been compromised, damaged or removed, staff must obtain a second opinion before the vessel is rejected.

5. For Vessels Completing the Thirty-Five (35) Day Quarantine Period Inside the Park Without Participating in the Tamper-Proof Tag Program

Any vessel returning to the park without participating in the Tamper-Proof Tag Program must complete the inspection and thirty-five (35) day Quarantine period.

CASITAS MUNICIPAL WATER DISTRICT
POLICIES & PROCEDURES FOR VESSEL DECONTAMINATION FOR AQUATIC INVASIVE SPECIES
LAKE CASITAS RECREATION AREA

Board Approved: 8/12/15 Effective Date: 8/12/15

Park Services Manager Approval: C. Belser Date: 8/12/15

General Manager Approval: Steve Wickstrum Date: 8/12/15

1. POLICY

All vessels and equipment entering the Lake Casitas shall be made free of invasive species, such as dressenid quagga mussels. Casitas Municipal Water District (Casitas) has determined that there are operational and emergency requirements that cannot accommodate a 35-day quarantine that is specified by the Lake Casitas Recreation Area Vessel Quarantine, Re-Entry, Temporary Storage and Tamper-Proof Tag Program (Quagga Prevention Program). Casitas has determined that specific alternative decontamination methods can be applied to remove the risk of invasive species entering Lake Casitas and to lessen or remove the quarantine period.

The appropriately assigned Casitas staff are authorized under the procedures of this policy to perform inspection, alternative decontamination, and risk mitigation compliance of vessels and equipment belonging to Casitas and Casitas approved public agencies or agents that are performing under a Casitas agreement or contract.

The alternative decontamination procedures shall not be applied to recreational vessels belonging to the general public. The Lake Casitas Recreation Area Vessel Quarantine, Re-Entry, Temporary Storage and Tamper-Proof Tag Program Casitas Vessel Inspection and Tagging Program is the standard for such vessels.

Any deviation from the decontamination policy or the procedures will require a timely written submittal to the General Manager that includes, but is not limited to, a request for deviation naming the key persons in control of the vessel or equipment, evaluation of the risk posed by the vessel/equipment, supporting factual documentation, a justification for the deviation and an assessment of the risk that is associated with the deviation. A request for a deviation to the policy may not proceed without the written approval of the General Manager.

Emergency or life-threatening situations will be processed as expeditiously as possible within established decontamination protocols that are addressed in Memorandums of Understanding with Federal, State and County emergency response agencies.

2. PROCEDURES

A. **Notification**. It shall be incumbent upon the responsible Casitas Manager to:

(a) Provide a timely request to the Park Services Manager for inspection and decontamination services to be rendered by the Lake Casitas Recreation Area (LCRA) staff; and

(b) Provide correct information for the person(s) to contact and the purpose of the vessel entry.

When an emergency is deemed to be occurring and entry to Lake Casitas is required by emergency responders, the emergency response agency shall:

(c) Contact the Park Services Manager by direct telephone call to request access, state the emergency and requirements and methods to access Lake Casitas; and

(d) Comply with all pre-arranged decontamination procedures prior to accessing Lake Casitas waters.

In case of an emergency, the Park Services Manager will immediately notify the General Manager and follow up with a written report of the emergency action and measures taken to comply with this policy.

B. **Inspection and Decontamination**. In order to be consistent with policies, procedures and training, the Lake Casitas Recreation Area Vessel Decontamination Checklist will be completed on all vessel inspections and decontaminations. This document outlines the process that staff must complete before a vessel of any kind is authorized to enter the LCRA and launch in Lake Casitas. Each step in the Vessel Decontamination Checklist has specific expectations associated with it and will only be conducted by fully trained and Casitas approved staff. LCRA staff will follow a zero tolerance policy for completing the decontamination procedures following current Pacific States Marine Fisheries Commission (PSMFC) Watercraft Inspection Training II (WIT II) standards.

C. **Documents**. The Vessel Decontamination Policies and Procedures, Vessel Decontamination Procedures, Vessel Decontamination Checklist, Vessel Inspection Policies and Procedures, Vessel Inspection Checklist, Vessel Acknowledgement Forms and Casitas handouts have been developed to ensure proper inspections of vessels, trailers and vehicles to prevent Lake Casitas from becoming infested with invasive species. All documents pertaining to the Vessel Inspection and Vessel Decontamination Policies and Procedures are subject to change due to updated policies at the sole discretion of Casitas.

D. **Vessel Inspection and Decontamination Checklist**

(a) Staff will complete a Casitas Municipal Water District Clean and Dry inspection following the Policies and Procedures for Vessel Inspections for Invasive Species.

(b) Staff will write the state boating identification number and owner/operator's name and date on the Vessel Decontamination Checklist.

(c) Staff will check the Casitas generated database of vessels that have previously been denied access.

(d) Staff will request the owner/operator of the vessel to open all compartments.

(e) Staff will request the owner/operator of the vessel to remove all equipment or gear from the vessel.

(f) Should the owner/operator refuse to allow a complete inspection and decontamination, access to the LCRA and Lake Casitas shall be denied.

(g) The decontamination shall be performed at a location designated by Casitas that will not drain directly into a waterbody.

(h) Staff will decontaminate the vessel, trailer and vehicle with a hot water wash with water temperatures ranging from 120 degrees F to 140 degrees F on high and low pressures depending on the area of the vessel being washed as listed below. The hot water wash will comply with current (PSMFC WIT II) standards.

E. **Areas of Decontamination**. The following areas will be decontaminated by Staff:

(a) **Vehicle Rear**: The vehicle bumper, tailgate or spare tire may have mud, grass, weeds or other debris on it. If there are positive signs of mud, etc., the area will be decontaminated with a hot water wash using low pressure in compliance with (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(b) **Trailer Structure, Railings and Spare Tire**: The trailer, railings and spare tire may have mud, grass, weeds, debris or standing water. The area will be decontaminated with a hot water wash using high pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(c) **Vessel Hull**: The vessel hull will be inspected for growth and debris. Growth may be visible if the vessel has been in the water for an extended period of time. Small mussels attached to a vessel can feel like sandpaper or sesame seeds. The area will be decontaminated with a hot water wash using high pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(d) **Transom**: The transom is at the back of the vessel where the engine is attached. The transom may have several items of importance for inspection that mussels can attach to including outdrive, trim tabs, transducers, bilge plug area and through hull fittings. The transom must be checked to make sure the surface is smooth and visibly clear of all debris and growth. All areas will be decontaminated with a hot water wash in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. A high pressure wash will be used on all areas other than the transducers (see below). An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(e) **Outdrive**: The Outdrive is attached to the transom on stern drive vessels and the lower unit on outboard vessels. It has intricate parts that make it easy for mussels to attach, hide and grow. Staff will feel and look for any signs of growth, debris or texture of sandpaper. The area will be decontaminated with a hot water wash using high pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(f) **Propeller/Shafts**: Mussels can attach and live on or around where the propeller attaches to the lower unit of the drive shaft. Mussels can also attach to the shaft or connecting points of the vessel. These can be hard to see and must be inspected with a flashlight to verify if any mussels, debris or water are present. The area will be decontaminated with a hot water wash using high pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(g) **Trim Tabs**: Trim tabs are located on the lower portion of the transom and are usually metal plates that help stabilize the vessel while underway. Staff will feel the corners, edges and look on the underside of the trim tabs for debris and growth. The area will be decontaminated with a hot water wash using high pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(h) **Transducers:** These are located on the transom or bottom of the hull near the stern of the vessel. They are used in conjunction with a computer to determine depth, speed and water temperature. Growth or debris can appear on them. The area will be decontaminated with a hot water wash using low pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(i) **Bilge Plug**: If the bilge plug is pulled when the vessel arrives at the lake, there should be no fluid or debris coming from it. Staff will check to determine if debris is blocking water from exiting. If the bilge plug is not pulled, the owner/operator will be requested to pull the plug. The area will be decontaminated with a hot water wash using high pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(j) **Through Hull Fittings**: Through hull fitting in all boats have the potential to store mussels in the right conditions. To check these fittings, Staff will use a flashlight to look inside and feel for irregularities. The area will be decontaminated with a hot water wash using low pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(k) **Bait Tank/Live Well/Compartments**: Bait tanks, live wells and compartments should be dry and clear of all water and debris. Some compartments do not drain completely due to

the way they are manufactured. Any debris in compartments is not acceptable. Common debris often found includes; fish scales, weeds, small pebbles, and trash. The area will be decontaminated with a hot water wash using low pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(l) **Bilge**: The bilge is at the bottom of the inside stern of the vessel. It may not be visible in all boats due to various boat designs. The bilge should be clean from all water and debris. The area will be decontaminated with a hot water wash using low pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(m) **Anchor/Fenders and Line**: Anchors can have mud or debris on them. If an anchor, fender and lines attached have been in infested water for an extended period of time then mussels and debris can attach. Staff must check these items for mud, growth and debris. The area will be decontaminated with a hot water wash using low pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(n) **Trolling Motor**: Trolling motors can pick up plants and debris while being used and must be inspected. These items must be checked for mud, growth and debris. The area will be decontaminated with a hot water wash using high pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

(o) **Engine:** The engine will need to go through a hot water wash to insure no contaminated water or invasive species are present in the engine. The appropriate attachments will need to be connected to the engine to insure no damage is done. Cold water will need to be run through the engine while it is running until the engine is appropriately "warmed up". Once the engine is "warmed up" the hot water wash can begin. The engine will be decontaminated with a hot water wash using low pressure in compliance with current (PSMFC WIT II) standards as may be modified from time-to-time. An infrared thermometer will be used to confirm the appropriate temperature has been reached. (See attached for current temperature requirements.)

F. **Compliance**

(a) If for any reason the decontamination is unable to be completed or there is good reason that Casitas staff believes that a risk still exists, the vessel will be denied entry into the LCRA and launching into Lake Casitas pending further review of the vessel's condition and determination of a remedy. Staff will provide to the Park Services Manager and General Manager, in a timely manner by written report, all reasons and concerns that staff has identified, remedies staff recommends for decontamination, or reasons that decontamination cannot be attained by the alternate decontamination method. If the vessel is denied entry due to an incomplete decontamination, the General Manager's direction must be obtained prior to any subsequent decontamination.

(b) Upon successful completion of the inspection and decontamination process,

the vessel will be secured until the time the vessel is launched into Lake Casitas. Securing a vessel may include, but not be limited to, vessel cabling and tagging in accordance with the Casitas Quagga Prevention Program, or temporarily storing the vessel in a Casitas approved secure area at either the LCRA or Casitas Dam. If the removal of the cable-tag or removal of the vessel from the secured area causes Casitas to determine that the vessel decontamination has been compromised, re-inspection and decontamination will be required. Such a determination shall be immediately reported to the General Manager prior to proceeding with launching the vessel. The Vessel shall be denied entry into Lake Casitas until full disclosure is provided and a clearance for re-inspection and decontamination is given by the General Manager.

G. **Decontamination of Field Equipment**. This protocol applies to all dive gear used in all water bodies, not just water thought to be infested. Decontamination of field equipment shall occur prior to conducting field work in Matilija Canyon, upstream of Matilija Dam, Coyote Creek upstream of Casitas Dam, Santa Ana Creek upstream of Casitas Dam, and Lake Casitas.

Field equipment requiring inspection and decontamination includes equipment associated with wading, scuba, snorkeling and surface supplied air (SSA) activities. The alternative decontamination protocols adopted are specified in Attachment B hereto - Bureau of Reclamation Technical Memorandum No. 86-68220-07-05, entitled "Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species" (2012 Edition).

Field staff may also apply 100% vinegar in a 20 minute dip bath or apply a 200 ppm chlorine bleach solution with a 10 minute contact time to achieve the decontamination of field equipment. The field personnel are cautioned, with the application of vinegar or chlorine, to thoroughly flush the field equipment with clean water. Residual vinegar or chlorine is unhealthful to breathe.

Waders and wading boots are a likely vector for transmission of invasive species, extra precautions are to be taken with boots. In addition to cleaning and washing, waders and wading boots are to be soaked in a saltwater bath for a minimum of 30 minutes. After soaking, the waders and wading boots are to be rinsed with freshwater. Snorkel gear is generally used one day per month to conduct surveys. All snorkel gear is to be cleaned with a mild detergent and rinsed with tap water. Generally this gear is dried for 35 days or more before the next survey.

A California Department of Fish and Wildlife (CDFW) study, Hosea and Finlayson 2005, found that bleach had deleterious effects on waders and wading boots. In addition, CDFW found bleach is ineffective for decontamination of New Zealand Mud Snail. NZMS has been observed in the Santa Clara River and in several streams in the Santa Monica Mountains. NZMS has been found to have a negative impact on trout.

Field staff shall document the application of the alternative decontamination protocol for each field equipment, date and location of field equipment use and date of decontamination being performed. The decontamination documentation shall be formally recorded and controlled by the Casitas Manager who is responsible for the field staff. The documentation shall be readily available for review at any time by the General Manager.

ATTACHMENT A

PACIFIC STATES MARINE FISHERIES COMMISSION (PSMFC)

WATERCRAFT INSPECTION TRAINING II (WITII) STANDARDS

AS OF MAY 2015

Area	Pressure	Temperature to Reach Degrees Fahrenheit	Confirm with Infrared Thermometer
Vehicle Rear	Low	120˚	Yes
Trailer Structure, Railings & Spare Tire	High	140˚	Yes
Vessel Hull	High	140˚	Yes
Transom	High	140˚	Yes
Outdrive	High	140˚	Yes
Propeller/Shafts	High	140˚	Yes
Trim Tabs	High	140˚	Yes
Transducers	Low	120˚	Yes
Bilge Plug	High	140˚	Yes
Through Hull Fittings	Low	120˚	Yes
Bait Tank/Live Well/Compartments	Low	120˚	Yes
Bilge	Low	120˚	Yes
Anchor/Fenders & Line	Low	120˚	Yes
Trolling Motor	High	140˚	Yes
Engine	Low	140˚	Yes

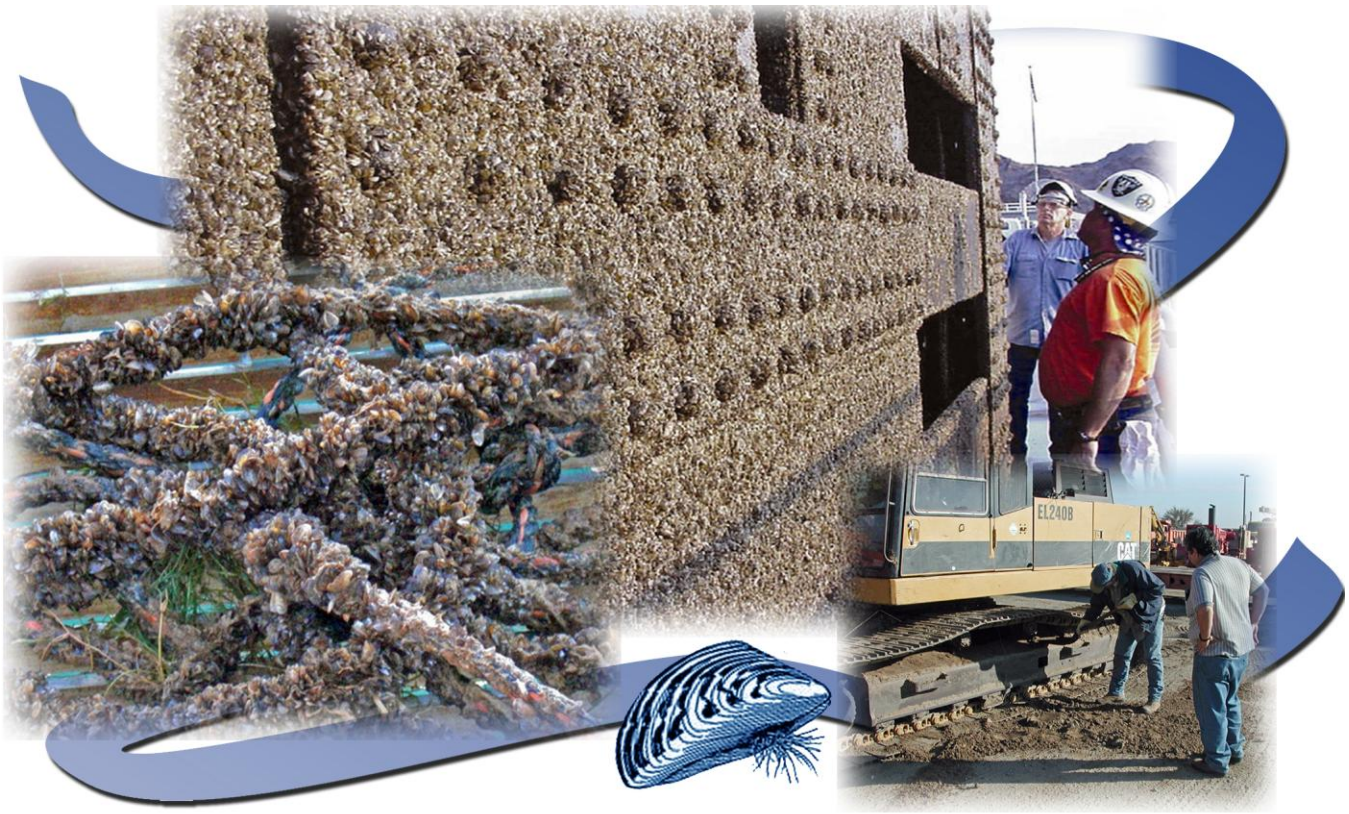
RECLAMATION

Managing Water in the West

Technical Memorandum No. 86-68220-07-05

Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species

2012 Edition



U.S. Department of the Interior
Bureau of Reclamation

June 2012

Technical Memorandum No. 86-68220-07-05

Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species

2012 Edition

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U.S. Department of the Interior
Bureau of Reclamation
Policy and Administration
Denver, Colorado

June 2012

MISSION STATEMENTS

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

DISCLAIMER

This manual is intended as an introduction to its subject matter and as a reference tool. It does not create or alter policy or otherwise implement any law and should not be cited as a source of authority. The information contained herein, regarding commercial products or firms, may not be used for advertising or promotional purposes and is not to be construed as an endorsement of any product or firm by the Bureau of Reclamation or the Department of the Interior. Firms, brands, or products that are not listed are not deemed unsatisfactory. Invasive and pest species listed herein do not constitute a complete list of such species.

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NOTICE OF AVAILABILITY

This manual is available and intended as an online resource. The manual uses many live hyperlinks that take the reader to additional information sites and video training. Frequent updating of the manual is expected, made necessary by new research findings and development of better methods. Although hard copies of the manual may be printed by the reader from the online source, any printed information may become rapidly obsolete without notice and would lack hyperlink usability. This 2012 edition supersedes all previous versions.

Cover photo: Precleaning heavy soil accumulations on tractor tracks, mussels covering a penstock gate at Davis Dam, and adult quagga mussels covering a rope used in the Lower Colorado River (photos courtesy of Fred Nibling, Dave Arend, and Joe DiVittorio, respectively).

Subject Directory

To assist you in finding frequently researched topics in this manual, we have provided this subject directory, as well as Contents pages located at the beginning of the main report and each appendix. In addition, you may enter a keyword into the Adobe Acrobat™ find field for a complete topic search of the manual.

Acknowledgments

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Authorities

Federal Noxious Weed Act of 1974 (sections 1 and 15), 7 U.S.C. 2814

Federal Insecticide, Fungicide and Rodenticide Act, as amended by the Food Quality Protection Act of 1996, 7 U.S.C. 136

National Invasive Species Act of 1996, 16 U.S.C. 4701

Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, 16 U.S.C. 4701

Plant Protection Act of 2000, 7 U.S.C. 7701 et seq. (supersedes the Federal Noxious Weed Act of 1974, except Sections 1 and 15)

Executive Order 13112, Invasive Species, *Federal Register*, February 3, 1999.

U.S. Department of the Interior's *Departmental Manual*

517 DM 1: *Integrated Pest Management Policy: Pesticides*
http://elips.doi.gov/ELIPS/DocView.aspx?id=1744
(Provides policy to all U.S. Department of the Interior bureaus, including the Bureau of Reclamation, for Integrated Pest Management activities involving the prevention, detection, and management of native and nonnative pest species, including invasive species, on Interior properties)

609 DM 1: *Policy and Responsibilities: Weed Control Program*
http://elips.doi.gov/ELIPS/DocView.aspx?id=1829
(Prescribes the policy to control undesirable or noxious weeds on the lands, waters, or facilities under its jurisdiction to the extent economically practicable, and as needed for resource protection and accomplishment of resource management objectives and the protection of human health)

Bureau of Reclamation's *Reclamation Manual*

ENV PO2 (Policy), *Pest Management*, December 23, 1996
http://www.usbr.gov/recman/env/env-p02.pdf
(Reclamation is responsible for the identification and proper management of pests on Reclamation lands and at Reclamation-owned facilities in accordance with the national policies set out in Federal Insecticide, Fungicide and Rodenticide Act; Federal Noxious Weed Act; Carlson-Foley Act; and applicable State and local laws and standards. This responsibility is to be fully considered in the development of a local Integrated Pest Management Program.)

ENV 01-01 (Directives and Standards), *Pest Management – Resource Protection (Integrated Pest Management) Program,* October 17, 1996
http://www.usbr.gov/recman/env/env01-01.pdf
(Provides directives and standards for Reclamation personnel involved with the implementation of Pest Management/Resource Protection plans for the operation and maintenance of Reclamation lands and facilities)

PEC 10-29 (Directives and Standards), *Reclamation Standard Water-Related Contract Articles, Article 29: Pest Management,* PEC 10-29, December 21, 2006
http://www.usbr.gov/recman/pec/pec10-29.pdf
(This article requires contractors to effectively control undesirable plants and animals on Federal project lands, project waters, and project works for which they have operation and maintenance responsibilities.)

Bureau of Reclamation's Acquisition Contract Guide Specifications

This page provides (Reclamation only) access to guide specifications and standard drawings used for preparing Reclamation construction and supply specifications. The guide specification adopts this Inspection and Cleaning Manual as the Reference Standard for equipment inspection and cleaning.

http://intra.usbr.gov/guidespecs

Path: CSI Masterformat 04; Division 1 - General Requirements; Use of Site - Section 01 14 10; 1.02 Reference Standards, and paragraph 3.01 –Cleaning."

Coordination with National-Level Plans

National Invasive Species Management Plan, 2008-2012. National Invasive Species Council, 2008. (Satisfies Plan performance element CM. 2.1.1., for increased cleaning treatments to slow the spread of invasive species.)

Strategic Plan 2007-2012, Aquatic Nuisance Species Task Force. 2007. (Satisfies Plan action 1.1a to develop strategies identifying and reducing the risk of harmful aquatic species being introduced into U.S. waters.)

Quagga-Zebra Mussel Action Plan for Western U.S. Waters, Aquatic Nuisance Species Task Force. Prepared by the Western Regional Panel on Aquatic Nuisance Species, 2010. (Satisfies Plan action items B.3. to develop Standard and Effective Equipment Inspection and Decontamination Protocols; and E.1. to Develop Tools and Best Management Practices for Preventing and Minimizing Mussel Movement and Settlement Within Water Distribution Systems and Other Infrastructure.)

Definition of Terms

Best Management Practice: A practice or combination of practices that is determined to be the most effective and practicable means of preventing or reducing undesirable results.

Desiccation: The state of extreme dryness or the process of extreme drying.

Exotic: Introduced from another country; not native to the place where found.

Flocculation: To cause to aggregate into a flocculent (loosely aggregated particles) mass.

Invasive species: Executive Order 13112, "Invasive species" means an alien species whose introduction does or is likely to cause economic or environmental harm, or harm to human health.

Invertebrate: Animals without a vertebral column.

Ion: An electrically charged atom or molecule due to the loss (a net positive charge) or gain (a net negative charge) of electrons. Metal ions such as copper and zinc have a net positive electrical charge.

Juvenile: Developing from the earlier veliger life stage (also see "veliger"), the juvenile is an immature life stage of a mollusk where settlement out of the water column to the substrate occurs. At this stage, the juvenile may attach to a surface and continue development toward adulthood.

Macrophyte: An aquatic emergent, submerged, or floating plant.

Mollusk (also spelled mollusc): A type of shellfish, such as a clam, scallop, or mussel. Mollusks having two hinged shells are referred to as a bivalve mollusk.

Nonindigenous species: Any species or other viable biological material that enters an ecosystem beyond its historic range, including any such organism transferred from one country into another.

Noxious weed: Any living stage, such as seeds and reproductive parts, of any parasitic or other plant of a kind, which is of foreign origin, is new to or not widely prevalent in the United States, and can directly or indirectly injure crops, other useful plants, livestock, or poultry or other interests of agriculture, including irrigation, or navigation, or the fish or wildlife resources of the United States or the public health. The term is usually defined as part of law, statute, or regulation.

Organism: Any living thing.

Pest: Any insect, rodent, nematode, fungus, weed, or any other form of terrestrial or aquatic plant or animal life or virus, bacteria, or other micro-organism (except viruses, bacteria, or other micro-organisms on or in living man or other living animals) which the Administrator (of the U.S. Environmental Protection Agency) declares to be a pest. . . which is injurious to health or the environment.

Propagate: The biological process of reproduction, may be sexual or asexual.

Propagule: Any plant material used for the purpose of plant propagation.

Rhizome: A horizontal stem of a plant that is usually found underground, often sending out roots and shoots from its nodes.

Species: A group of related organisms capable of interbreeding and producing fertile offspring.

Stolon: A specialized type of horizontal above-ground shoot, a colonizing organ that arises from an axillary bud near the base of the plant.

Veliger: The free-swimming immature life stage of a mollusk. As the veliger grows, it settles out of the water column to enter the later juvenile immature life stage (also see ~~"j~~uvenile").

Weed: A native or non-native plant that is unwanted in a particular place at a particular time**.**

Executive Summary

Procedures have been developed in this manual to address the transport of pest and invasive species through equipment movement. This manual provides uniform guidelines for inspecting and cleaning vehicles and equipment to help prevent the spread of pest and invasive species during Bureau of Reclamation (Reclamation) activities. The general types of equipment described in this manual are:

- Rubber-tired land vehicles
- Tracked land vehicles
- Personal use equipment
- Construction and facility equipment
- Watercraft

Before conducting any equipment inspection or cleaning action, the reader is urged to first review all introductory sections located at the beginning of this manual. In particular, the "Overview of Inspection Procedures" and the "Overview of Cleaning Procedures" sections provide valuable information. In addition, the "Inspection-Cleaning Relationship" flowchart (figure 17) is an extremely helpful resource that will detail the complex tasks of equipment inspection and cleaning. These two overview sections and figure 17 when taken together, will direct the reader elsewhere in the manual for in-depth discussion: appendix A for Inspection Standards and appendix B for Cleaning and Decontamination Procedures.

Reclamation operates water management facilities throughout the 17 Western States. Reclamation's mission objectives are the delivery of water, currently to more than 31 million people, and the generation of hydroelectric power, currently at approximately 44 billion kilowatthours of electricity produced annually. Preventing the spread of invasive species has a direct effect on these objectives, since pests and invasive species have the potential to adversely impact the flow of water and damage facilities.

The majority of Reclamation facilities were designed and constructed nearly 50 years ago, with some facilities now over 100 years old. Roughly coinciding with this period during the past 50 years, and as a consequence of improved transportation, the rate of invasive species colonization in the United States sharply increased, resulting from huge numbers of invasive species arriving from foreign locations. Early during the period of invasive species introduction, the impact from invasive species alone could not have been predicted as becoming a threat to Reclamation facility operations or mission. However, when combined with aging facilities and periodic drought, infrastructure that was once designed

specifically to deliver water and generate electrical power was not intended to cope with these unforeseen, multiple impacts. Clearly, climate conditions that may cause drought are outside our immediate control; aging facilities can be mitigated somewhat through continued preventative maintenance and replacement of components. Preventing pest and invasive species spread, however, is a tool fully within our reach for limiting impacts to Reclamation's mission. Preventing the spread of these species is a cost-effective approach because once these species becomes established or widespread, control may require significant and sustained budget expenditures for facility redesign, retrofitting, monitoring, and increased maintenance requirements.

Live adult quagga mussels taken from a wet well at a Lower Colorado River facility (photo courtesy of Joe DiVittorio, 2008).

The spread of pest and invasive species from one location to another has been linked to the use and movement of contaminated equipment. The recent introduction of the invasive zebra and quagga mussel from the Eastern watersheds of the United States into the Western watersheds is thought to be almost entirely by cross country movement of contaminated watercraft and other equipment, and highlights the importance of inspection and cleaning of all types of equipment.

As discussed in greater detail later in the manual, the concept of successful prevention is the goal of all equipment inspection and cleaning processes and is the main purpose of this manual. Prevention actions deny the entry of pest and invasive species into uninfested locations. This factor underpins all equipment inspection and cleaning methods to be discussed: through prevention, the spread of these species from one place to another can be limited.

Contents

Tables

Figures

Figures (continued)

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Organization of the Manual

This manual is organized to present equipment inspection techniques first, because inspection will determine the need for later cleaning. Equipment cleaning methods and protocols are explained next, including a discussion on the use of various equipment cleaning methods and products. Finally, the manual offers information on the identification and habitats of some common pest and invasive plant and animal species that are of high importance in the Bureau of Reclamation (Reclamation), which may be transferred by equipment use.

The general types of equipment described in this manual are:

- Rubber-tired land vehicles
- Tracked land vehicles
- Personal use equipment
- Construction and facility equipment
- Watercraft

Introduction

This manual provides uniform guidelines for inspection and thorough cleaning of vehicles and equipment that come in contact with pest and invasive species during Reclamation work. The information in this manual will help personnel to understand how pest and invasive plants and animals are spread and will provide instructions and recommendations to reduce their spread.

Equipment inspection and cleaning are examples of sanitation actions. Sanitation is identified as an Integrated Pest Management (IPM) cultural control tool in the Department of the Interior's *Departmental Manual* 517 DM 1 (U.S. Department of the Interior, 2007). In addition, cultural control is an IPM tool requirement found in the Food Quality Protection Act of 1996, Public Law 104-170, amendment to the Federal Insecticide, Fungicide, and Rodenticide Act, which states in part:

> Integrated Pest Management is ~~"a~~ sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks," and ~~"F~~ederal agencies shall use Integrated Pest Management techniques in carrying out pest management activities and shall promote Integrated Pest Management through procurement and regulatory policies, and other activities."

Further, Executive Order 13112 on Invasive Species (Order) of February 3, 1999 requires Federal agencies to –use relevant programs and authorities to: (i) prevent the introduction of invasive species."

The Order also established the National Invasive Species Council, and development of the National Invasive Species Management Plan, 2008-2012 (National Invasive Species Council, 2008). The findings of the National Invasive Species Council and the National Invasive Species Management Plan included the importance of preventing the spread of invasive species to minimize the staggering costs of management and control of widespread invasions:

> Prevention is the first-line of defense. It can be the most cost-effective approach because once a species becomes widespread; controlling it may require significant and sustained expenditures. Therefore, public investment in prevention tools, resources and infrastructure is indispensable in protecting human health, agriculture and natural resources.
>
> Long-term success in prevention will reduce the rate of introduction, the rate of establishment and the damage from additional invasive species in the United States.

Limiting the spread of pest and invasive species on Reclamation work sites can be a significant challenge. These species can be spread in numerous ways. For example, soil and mud that may accumulate on undersides of vehicles can carry seeds or viable fragments of pest and invasive plants. Lodged material from plants or animals is often not easily recognizable by casual inspection of equipment and vehicles. In addition, foreign material can become lodged in areas of limited sight and access. Also, the use of watercraft, pumps, in-water equipment, and even waders in waters infested with these species can easily become sources for spread. Therefore, it is vital that Reclamation personnel working in areas where pest and invasive species are present have sufficient training in inspecting and cleaning equipment. This Manual provides an effective self-help resource to personnel.

The Colorado Division of Wildlife has provided guidelines on watercraft cleaning procedures to prevent the spread of invasive species. These guidelines, known as the –Clean, Drain, and Dry" system, are adapted from Colorado Division of Wildlife (2009) and shown below.

Inspection of equipment is the primary tool for preventing the introduction of pest and invasive species into an uninfested location. Properly conducted inspection and cleaning of equipment prior to entry at a new location limits introduction of these species.

Inspecting and Cleaning Equipment

- Generally, equipment of all types should be cleaned at the location of last use before being moved to a new location. If this is not possible, arrange for cleaning at a facility that is specifically designed for equipment cleaning.
- If equipment is used at a location known to be infested with an invasive species, the equipment should undergo a preinspection, followed by thorough cleaning, and a final inspection before being moved off the worksite.
- At the new location, the equipment should be inspected again, preferably by someone other than the original inspector before the equipment is placed into service.
- If, on reinspection, contamination is found on the equipment, do not allow the equipment entry on the new worksite; either return the equipment to the location of last use for additional cleaning or arrange for cleaning at a location that is specifically designed for equipment cleaning.

Clean, Drain, and Dry!

Properly follow these guidelines. While on land, but before leaving a body of water:

Clean:

- Remove any visible plant or plant fragments, as well as mud or other debris. Plant material, mud, and other debris routinely contain other organisms that may be an aquatic nuisance species. Some plant species are aquatic nuisance species.
- Check trailer, including axel and wheel areas - in and around the boat itself: anchor, props and jet engines, ropes, boat bumpers, paddles.
- Clean and check and dry off all parts and equipment that came in contact with water.
- Using a car wash or home power water sprayer is not adequate to kill and/or remove zebra or quagga mussels.

Drain:

- Drain every conceivable space or item that can hold water.
- Follow factory guidelines for eliminating water from engines. All engines hold water, but jet drives on personal watercraft and other boats can hold extra water.
- Remove the drain plug from boats and put boat on an incline so that the water drains out.
- Drain live-wells, bilge, ballast tanks, and transom wells.
- Empty water out of kayaks, canoes, rafts, etc.

Dry:

- Allow everything to completely dry before launching into another body of water.

Background

Prior to preparing this manual, each Bureau of Reclamation region was asked to briefly describe the diverse kinds of equipment that were used for Reclamation work. The equipment types were identified and broadly grouped together. It is not possible to discuss all of the many and varied types of equipment in use throughout Reclamation. However, this manual does provide the process to preinspect, clean, and reinspect all equipment before moving or placing the equipment into service. During preparation of the manual, many concepts, methods, and products were discussed, and information was made available by other Federal agencies and other organizations.

Reclamation's mission objectives are the delivery of water and generation of hydroelectric power. Reclamation's 58 hydroelectric powerplants annually produce nearly $1 billion in power revenues and provide electricity to serve 6 million homes. In addition, Reclamation manages approximately 16,000 miles of canals, 280 miles of water transmission tunnels, 1,400 miles of pipelines, 37,500 miles of laterals, 17,000 miles of project drains, 348 storage reservoirs, 254 diversion dams, and 268 pumping plants rated at over 1,000 horsepower. Pests and invasive species can adversely impact mission objectives by disrupting waterflow or damaging water management infrastructure.

Approximately 50,000 nonindigenous species have been introduced to the United States, and many of them create serious economic and environmental damage (Pimentel et al., 2000). Economic implications include direct losses of agricultural and forestry assets, land-use capability, and human health, as well as escalating costs associated with managing the problems caused by invasions.

Invasive species can cause numerous environmental impacts from loss of functional habitat to loss of many native species, including rare plants and animals. The adaptive and competitive nature of exotic species, particularly in disturbed habitats, often leads to rampant spread. Many invasive species are spreading at alarming rates throughout the Western United States. Human activity facilitates spread, and infestations often start in areas where plants or animals have been moved by human activity. Boat ramps, highways, and recently disturbed areas are often the sites of early infestations.

Environmental impacts from invasive species are difficult to quantify in economic terms, but direct economic damages from the effects and control efforts of exotic species has been estimated at $137 billion per year in the United States (Pimentel et al., 2000). The way to mitigate further escalating costs to people and the ecosystem is to halt the further spread and introduction of invasive species in Reclamation project areas. Otherwise, environmental and economic impacts could greatly increase, causing more difficult challenges in the future.

Spread of Invasive Species Associated with Vehicles and Equipment

Pest and invasive species are often spread when humans move equipment to new areas. A comparison of figures 1 and 2 shows that the most heavily populated traffic routes in the United States correlate with increased zebra and quagga mussel sightings throughout the West (U.S. Department of Transportation, 2002; U.S. Geological Survey, 2011). For these mussels, the general pattern of infestation is overland transport by watercraft and in-water equipment via the highway system, then to a water body system, where the invasive species move with downstream waterflow.

Watercraft, vehicles, earth-moving equipment, pumps, trailers, and other equipment are particularly troublesome avenues of spread (figure 3). Clothing, shoes, waders, and diving gear can become vectors of spread when personnel leave infested areas that contain soil or mud laden with seed or plant fragments (figure 4). Invasive species can also be deposited on fuel tanks, wheel wells, and behind the bumpers of vehicles (figure 5). Pathogens, insects, and other animals can be transported in the same manner.

Tractors and mowers collect plant materials during operations in the field (figure 6). Tracked vehicles pick up large amounts of soil, mud, and debris, making them more of a challenge to clean than smaller vehicles and other equipment. Similarly, drivetrain belly pans of bulldozers accumulate large amounts of soil and debris, which might require physical removal of foreign material before washing. Physical removal of accumulated material (precleaning) before washing operations can help reduce water demand when cleaning certain equipment (figure 7).

Equipment use might involve not only Reclamation-owned equipment, but also rented equipment and equipment used by contractors and subcontractors (figure 8). Equipment also is brought in from other areas of the United States and may be transferred out to locations where new invasions may inadvertently accompany contaminated equipment.

Reclamation-owned, managing partner, contractor, subcontractor, and rental equipment used at Reclamation worksites must be inspected, and cleaned if necessary, to ensure that equipment arrives and leaves clean to prevent introduction or spread of pest and invasive species.

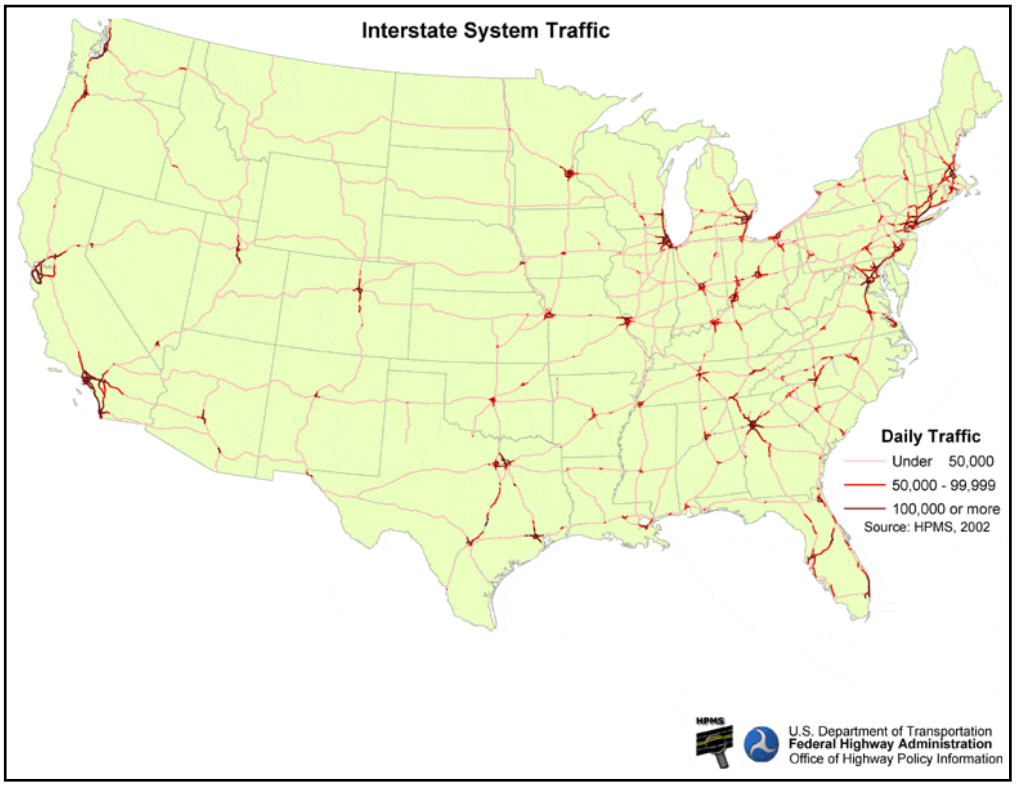

Figure 1. Daily interstate system traffic in the United States, 2002.

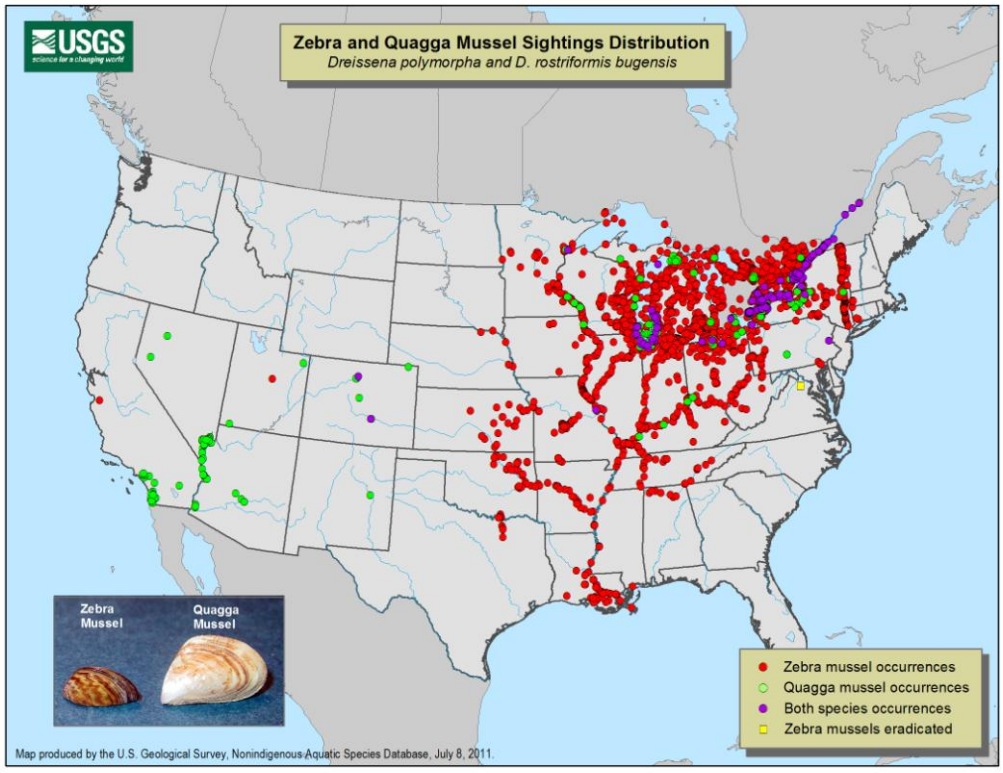

Figure 2. Zebra and quagga mussel finds in the United States, 2011.

Figure 3. Dozing operations taking place in Socorro, New Mexico, in an area occupied by the invasive species saltcedar (Bureau of Reclamation photo).

Figure 4. Mud encrusted on a shoe sole (U.S. Army Corps of Engineers photo).

Fuel tank

Wheel well and back bumper

U.S. Army Corps of Engineers

Figure 5. Potential areas of invasive species deposits on a tractor trailer (U.S. Army Corps of Engineers photo).

Figure 6. Plant material carried on brush mowing equipment (photo courtesy of Fred Nibling).

Figure 7. Precleaning heavy accumulations can help reduce water use when washing. Working in certain areas may require a safety lookout (photo courtesy of Fred Nibling).

Figure 8. Rental equipment may be delivered to a worksite with mud accumulations. Consider including equipment cleaning in the equipment rental contract (U.S. Army Corps of Engineers photo).

Facility Equipment Used in Water

Many facilities throughout Reclamation share common designs and components. Where these components have the potential of being used interchangeably at facilities from one location to another, there is a pathway of invasive species spread, particularly by zebra or quagga mussels. Any parts, components, or equipment being considered for use at another facility must be fully inspected for invasive mussels and thoroughly decontaminated before transport to the new location. Gates, valves, pumps, and structural components are examples of such items (figure 9).

Figure 9. Underwater photo showing mussels covering the Davis Dam domestic water intake grate (photo courtesy of LC Diving and Marine Operations, 2008).

In addition to the many in-water components that may be used interchangeably among Reclamation facilities, permanently installed out-of-water components that use raw water for various functions and processes may be vulnerable to zebra or quagga mussel infestation. This type of component is not likely to be disassembled and moved to another facility; therefore, it does not pose a mussel spread risk to other locations. However, a mussel infestation involving these components is likely to adversely impact facility operations in some way. Examples can include cooling water systems for mechanical or electrical components.

Raw water fire suppression sprinkler systems are another example of permanently installed systems at facilities that may be susceptible to mussel infestation. The

immature free-swimming life stage of the zebra or quagga mussel (veliger) is microscopic and can enter standard screened or grated raw water intakes during regular sprinkler system performance testing. If you are not familiar with the life cycle of these mussels, refer to appendix C, pages C-103 through C-111, for more information. Once inside an unprotected sprinkler system, it is possible for the veliger mussel to grow into an adult mussel. There, even years after initial infestation of the sprinkler system takes place, the shells of dead mussels can block sprinkler openings or clog pipes if the system is triggered during a fire emergency (figure 10). It is highly recommended that raw water intakes be equipped with reliable mussel prevention measures.

⚠ A mussel contaminated sprinkler system may pose a high risk for life and property.

Backgrounder!

Click here (or see page 21) to learn more about how mussels might present a danger to fire protection sprinkler systems.

Figure 10. This raw water fire protection sprinkler system, located on the former Philadelphia Naval Shipyard, is contaminated with aquatic organisms and debris. Raw water that contains zebra or quagga mussels can enter a sprinkler system intake, where the mussels can grow and clog the sprinkler heads (photos courtesy of John Breuer, 2000).

In particular, attention should be given to water bags used during crane testing and calibration at various Reclamation facilities (figures 11 and 12). Crane testing companies often use water bags by filling the bag with water to the corresponding weight for the testing process. These bags can be used at various locations across the country and might be filled with untreated raw water at the location of last use. At the end of crane testing, the bag is drained and can be moved to a new location. If not properly handled, water bags can become a pathway of aquatic invasive species spread.

Figure 11. Crane testing at Glen Canyon Dam (photo by Gerry Jarin; photo courtesy of Jim Jota, Imes, Inc., 2005).

Figure 12. Crane being tested at a Tennessee Valley Authority powerplant using water weight bags™ (photo by Mike Hoffman; photo courtesy of Jim Jota, Imes, Inc., 2002).

Remember to follow the "Clean, Drain, and Dry" recommendations supplied in the Introduction section of this manual. Further information can also be obtained by visiting the 100th Meridian Web site (100th Meridian Initiative, 2011).

Work in aquatic environments, whether reservoirs, rivers, or conveyance channels, presents different challenges than in terrestrial areas. Invasive species can become lodged in or on personal gear, including diving gear; watercraft; and other conveyances, as well as associated equipment, trailers, and towing vehicles (figures 13 and 14). Since invasive aquatic plants often spread from fragments, special care must be taken to identify and address these issues before leaving a water body. Invasive aquatic species, such as the zebra and quagga mussel, can spread relentlessly and require special inspection and cleaning methods. Rigorous inspection must be used to find problems, and total removal of potential invaders must take place before moving to other aquatic systems.

Figure 13. Mud and debris on pump (above) and hydrilla on boat trailer (below) (photo courtesy of Fred Nibling).

Figure 14. Hydrilla can block the flow of water in rivers, creeks, and channels. It can be spread to new locales by vegetative fragments and propagules carried on contaminated equipment and watercraft. Lower Rio Grande River (photo courtesy of Fred Nibling, 2001).

Overview of Inspection Procedures

Prior to beginning any cleaning or decontamination action, be sure to first review appendices A and B.

Inspection procedures are developed in this manual to systematically address transport of invasive species and pests through equipment movement. This manual provides personnel with necessary information to identify areas of concern on vehicles and many types of equipment. In addition, personnel may require inspection training for specific invasive species. Inspection should include precleaning, monitoring cleaning procedures, and postcleaning.

Best Management Practice:

Properly conduct inspection of equipment prior to entry at a new location to prohibit introduction of invasive organisms.

First inspections of equipment, especially at field sites, could potentially overlook hard to find areas. Therefore, after equipment is cleaned, a more detailed inspection could reveal overlooked soil and mud (potentially laden with invasive plant seeds or other invasive propagules) in hard to reach areas of equipment. For example, on vehicles and tractors, look under wheel wells, behind bumpers, on radiators, on tracks, or above drivetrain belly pans.

Each equipment type has its own particular requirements for inspection. There are many similarities among rolling stock vehicles, whether wheeled or tracked, that have common design features that are prone to accumulating soil, mud, and other foreign material. The vehicle depicted in figure 15 appears to be clean on casual inspection, but upon closer examination (figure 16), the mud deposits on

Figure 15. Tracked military equipment wash bay with hardstand surface and access underneath equipment (U.S. Department of Defense photo, 2004).

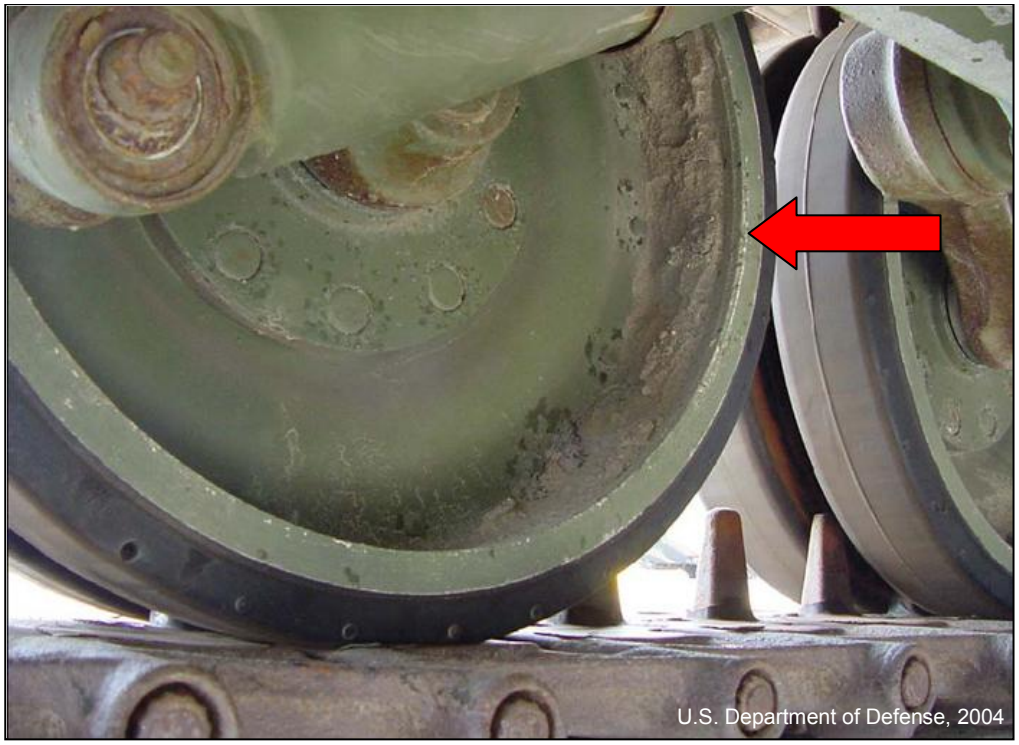

Figure 16. Postcleaning inspection found remaining contamination on this tracked vehicle (U.S. Department of Defense photo, 2004).

the track rollers can be a source of infestation. Casual observation will not address hidden areas of concern. Figure 16 illustrates the value of an equipment postcleaning inspection.

- Watercraft, other in-water equipment, and facility equipment have specific inspection needs and will be covered more extensively in appendix A.

- Even the most careful inspection of any equipment will not guarantee that the equipment is absolutely free of contamination.

Overview of Cleaning Procedures

Prior to beginning any cleaning or decontamination action, be sure to first review appendices A and B.

This section briefly discusses the procedure for cleaning personal gear, vehicles, and equipment. These procedures can be used in the field. Appendix B contains more detailed information on cleaning and decontamination, as well as recommendations for selecting a washdown location.

Best Management Practice:

Equipment of all types should be cleaned at the location of last use before being moved to a new location.

Watercraft, other in-water equipment, and facility equipment have specific cleaning needs and will be covered more extensively in appendix B.

Precleaning, by removing heavy accumulations of soil and debris with appropriate tools, will save water during later washing operations. Effective cleaning to eliminate invasive species materials and prevent their spread can be accomplished by thoroughly removing soil and debris using pressurized water. In certain situations, cleaning with compressed air, rather than water, could prevent damage to certain equipment areas such as engine wiring systems and vehicle cabs.

Controlling other invasive species may require chemical treatment. Chlorine, flocculation, and ozone are substances that have been used to kill certain pest and invasive species. Use of chemical treatments sometimes poses disposal and wastewater concerns. If chemical treatments are used, local standards of waste disposal must be followed. In addition, States may require certification or licensing for personnel who use chemical treatments for these purposes.

Despite very careful efforts to capture and quarantine materials from cleaning operations, site-specific invasions are likely to occur. For example, perimeters of remote cleaning areas could benefit from silt fencing to filter wash water when

cleaning certain kinds of equipment. Postcleaning monitoring of these areas is recommended.

Ideally, equipment for cleaning operations should be portable, with the built-in ability to move cleaning stations to remote sites. Progress has been made in developing and deploying portable cleaning systems. Several examples of current technology and use are given in appendix B for information only (not as endorsements), and the list is not to be considered exhaustive or complete.

Table 1 discusses various invasive species that can cling to equipment and summarizes inspection and cleaning processes. The Inspection-Cleaning Relationship flowchart (figure 17) details inspection and cleaning pathway actions.

Safety Notice!

Personnel who use equipment during cleaning operations are responsible for properly using PPE to protect against hazards.

Personnel who use equipment during cleaning operations are responsible for properly using Personal Protective Equipment (PPE) that is appropriate to the cleaning activity. Using cleaning and disinfectant chemicals, power washers, air compressors, and other types of cleaning equipment may present unique working hazards. PPE items may be required to protect hearing, skin, eyes, respiration, and other body resources. For example, certain types of cleaning equipment may require electrical power and may present electrical hazards to the operator. Power washers operate at very high pressures and are capable of causing serious bodily injury.

- Users of all cleaning equipment must become completely familiar with operating the equipment before attempting its use.

- Not only must the user be familiar with inspection and cleaning equipment, but also with the equipment item to be inspected and cleaned. Use extreme care when working with and around all unfamiliar equipment.

- Consult all appropriate information sources and follow all manufacturers' notices, as well as *Reclamation Safety and Health Standards* (Reclamation, 2001).

Even the most careful cleaning of any equipment, however, will not guarantee that the equipment is absolutely free of contamination. Successful cleaning is dependent upon many factors, such as the amount of care taken during the cleaning operation, the type of cleaning equipment being used, the level of training of the cleaning operator, the type of equipment being cleaned, and the particular invasive species.

Table 1. Summary of inspection and cleaning for personal gear, watercraft, trailers, vehicles, and other equipment

What Needs to be Inspected and Cleaned				
		Personal Gear	Watercraft and Trailers	Vehicles and Equipment
Types of Confirmed or Suspected Pest and Invasive Species	Submersed and floating aquatic plants	Inspect: Look for plant material, stalks, or fragments on all surfaces, inside and out. See appendix A. Clean: Various methods depending on the equipment. See appendix B.	Inspect: Look for plant material, stalks, or fragments on all surfaces, inside and out. See appendix A. Clean: See appendix B.	Inspect: Preclean to remove large debris to provide better visual access to inspect equipment for foreign matter. See appendix A. Clean: Various methods depending on the equipment, see appendix B.
	Emergent aquatic	Inspect: See above. Clean: See above.	Inspect: See above. Clean: See above.	Inspect: See above. Clean: See above.
	Wetland	Inspect: See above. Clean: See above.	Inspect: See above. Clean: See above.	Inspect: See above. Clean: See above.
	Riparian plants	Inspect: See above. Clean: See above.	Inspect: See above. Clean: See above.	Inspect: See above. Clean: See above.
	Mollusks	Inspect: See appendix A. Clean: See appendix B.	Inspect: See appendix A. Clean: Drain bilge water and dry watercraft and trailer. See appendix B.	Inspect: Search for veligers attached to surfaces. See appendix A. Clean: Wash surfaces with water heated to a minimum 140 °F. See appendix B.
	Terrestrial plants (dry habitat only)	Inspect: For all clothing, turn out pockets; remove seeds and burrs from all socks, shoelaces, and shoe tongues. See appendix A. Clean: Clean as indicated. See appendix B.	Inspect: See appendix A. Clean: See appendix B.	Inspect: Prior to inspection, preclean to remove large debris with tools. See appendix A. Clean: Various methods depending on the equipment. See appendix B.

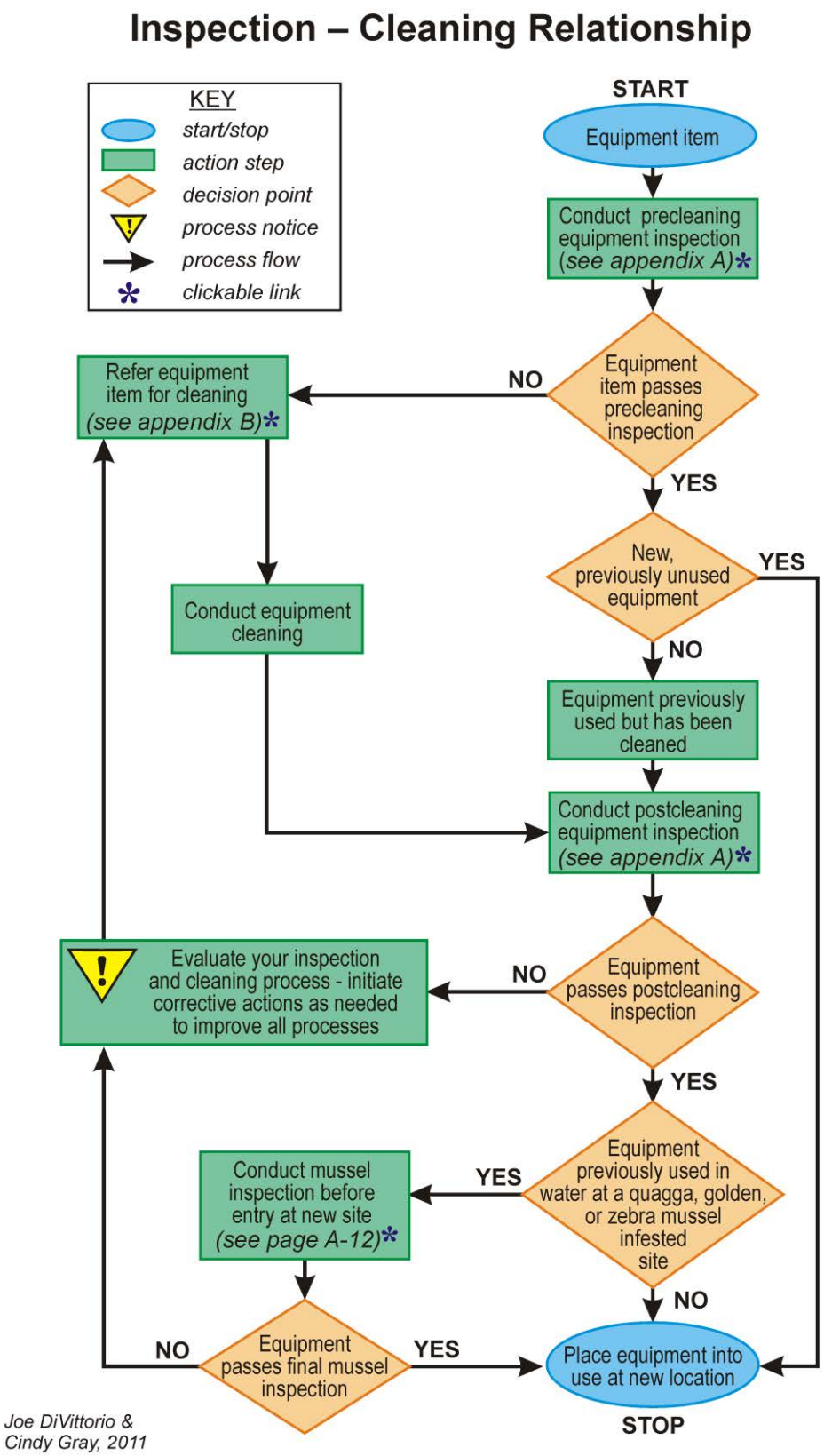

Figure 17. The inspection-cleaning relationship.

Overview of Species of Concern

Plants and animals spread through a variety of mechanisms. For plants, seeds, fragments, roots, tubers, rhizomes, and stolons are common materials which facilitate reproductive and migratory strategies. Invertebrates, clams, mussels, snails, and other animals often accompany plants, mud, and other materials. Many animals can attach directly to personnel and equipment (figure 18) (Cofrancesco et al., 2007). Regardless of mode of transport, unintentional spread of all invasive species can be managed by removing and isolating them before moving into uninfested areas. Therefore, rigorous inspection and cleaning before leaving a worksite is the best approach, no matter which species are of concern.

Figure 18. Snails directly attached to wheel and tire (photo courtesy of Al Cofrancesco, 2006).

More detailed information on invasive species that are known to be problematic in the Western United States and are likely to present invasive species issues for Reclamation are listed in appendix C.

Backgrounder!

Fire Protection Sprinkler Systems

Although not contaminated with either zebra or quagga mussels, figure 10 provides an unusual glimpse of a contaminated dry-pipe fire protection sprinkler system discovered after disassembly. The contamination seen is composed of dead aquatic organisms and silt. In this case, the contamination is so great that portions of the system may not have operated during a fire emergency.

This system protected a two-story building with attic space that was constructed in 1920 and located on the former Philadelphia Naval Shipyard. Other than floating course-mesh screens at the high-pressure fire pump intake on the Delaware River, there was no other water filtration or treatment; therefore, this system is termed a ~~"r~~aw water" system.

Water is not present in the piping of a dry-pipe fire sprinkler system until the system operates. At rest, the piping system is pressurized only with air. The entire system would normally fill with water anytime the system is deliberately tripped (as during testing or in a fire situation) or when accidentally tripped (due to loss of air pressure or a supply water pressure surge or water hammer).

There are two unique findings about this system: first, the heaviest contamination accumulation is in the attic piping, with little accumulation in the lower floor piping. Fire protection systems engineers have speculated that whenever the system was tripped for various reasons through the years, high-velocity, in-rushing water carried the contamination up to the top of the system located in the attic space. When the water reached the end of the piping, the water slowed, then stopped moving, allowing the contamination load to settle out. After each fill-up episode, the system was reset and drained. However, the velocity of the water drained off under gravity flow was less than that needed to carry the contamination out of the system. Secondly, a properly maintained fire sprinkler system is tested regularly. While this system apparently passed all prior testing, the contamination that was lodged only in the upper attic portion of the system was not detected through normal testing methods.

This example provides insight for facilities where raw water is currently being used, or may have been used in the past, to supply fire protection sprinkler systems. Since infestation of zebra and quagga mussel in a water body can go undetected for years, it is possible that the fire protection system could be tripped, and the system could become inadvertently contaminated. Using the former

Philadelphia Naval Shipyard fire sprinkler system as a model of what could potentially happen, it is possible that a zebra or quagga mussel contaminated fire protection sprinkler system would not be detected during regular testing.

Recommendations:
1. More extensive testing may be advisable if there is any doubt about the integrity of a possibly contaminated system.

2. Consult a fire protection systems engineer.

3. Consider converting a raw water supply to a treated water supply.

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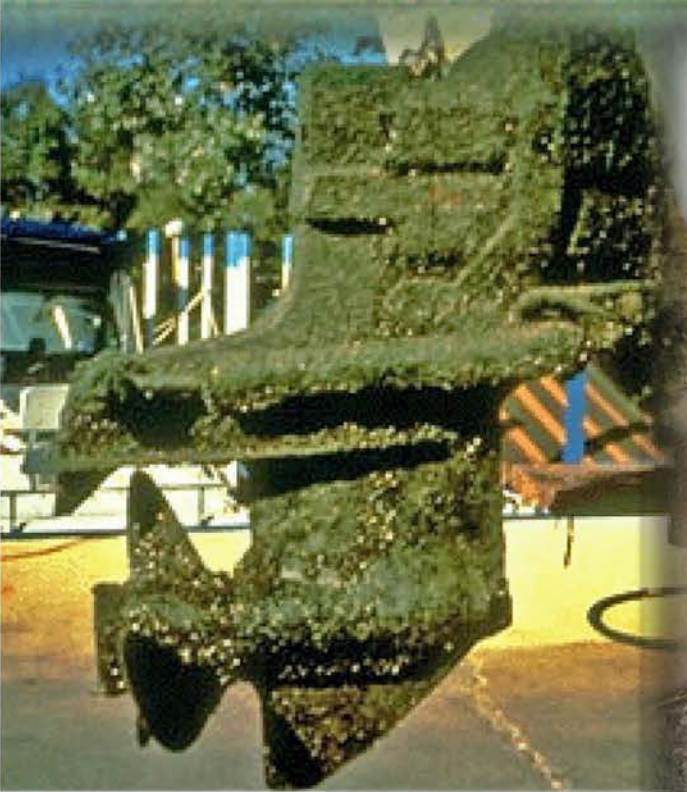
Appendix A
Inspection Standards



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Appendix A
Inspection Standards

Prior to conducting an inspection, be sure to review the "Overview of Inspection Procedures" section, figure 17, and applicable portions of appendix A.

Personnel must be trained to look for problem areas that are not apparent upon casual observation. Effective inspections require good lighting (preferably daylight hours), training of personnel to use systematic techniques, and developing checklists of potential problems. Effective inspections also require persons who have the task of inspecting vehicles, equipment, and personnel to be dedicated and accountable for their actions. The equipment inspection must include all areas, including those areas that are difficult to reach and see into.

How to Inspect

Identify and train personnel to be responsible for inspections at field sites. Training for watercraft inspection and cleaning is periodically announced on the 100th Meridian Initiative Web site (http://www.100thmeridian.org). Inspections should be carried out on personal gear, equipment, and vehicles at a staging area dedicated to equipment and vehicle cleaning. Precleaning inspections can identify problem areas and determine whether hand removal of large accumulations of soil and debris is necessary before washing. Postcleaning inspections can verify that all materials deemed capable of spreading invasive species have been eliminated.

Include an inspection process for vehicles and equipment that arrive onsite from other areas. Equipment from rental agencies, outside contractors, and managing partners are subject to inspection as well.

Appropriate equipment needed for inspections may include flashlights, under-vehicle mirrors, PPE, remote probe viewer cameras, various hand tools, checklists of invasive species likely occurring at site of last equipment use, and portable lighting.

Budget work to account for rigorous inspections as a component of costs. Preventing an invasive species is much less expensive than the cost of controlling and managing an invasive species after it has become established.

Tools for Inspection

The following is a list of some sources providing specialized inspection equipment. No endorsement of these products or companies is implied.

Return to Inspection-Cleaning Flowchart

Under-vehicle inspection mirrors:

Reflection Products, Inc.
1505 N. Richmond Rd.
McHenry, IL 60050
770-642-2104
http://www.reflectionproducts.com/

Under-vehicle inspection cameras:

Con-Space Communications
1160 Yew Avenue, PO Box 1540
Blaine, WA 98231
1-800-722-2824
http://www.con-space.com/searchcam/searchcam-overview

Site Inspection

Costs and time considerations will likely conflict with the ability to consistently perform rigorous inspections at all field sites. Contingencies, such as inclement weather, field emergencies, and other unknown factors, can further hamper the ability to perform rigorous inspections. Protocols for dealing with contingencies need to be defined and included in the inspection process.

Mulches, Straw, and Hay

Hay and straw materials are often relatively inexpensive and effective mulch treatments (figure A-1). Require that hay, straw, and seed used for soil erosion control on construction sites and for all other soil stabilization work be weed-free certified.

Desirable hay composed of native species may be available in some areas. Along with the advantages, use of hay has some disadvantages as well. Because hay products can introduce undesirable weeds or exotic species, carefully check the certification of products prior to purchase or contract award. For hay mulch, a list of certified weed-free hay producers is typically available through most State agriculture departments.

Small grain straw is often used as a common substitute for hay mulch. However, inclusion of grain seed in straw materials should not be accepted. Such seed increases competition with intentionally planted species. In addition, do not use aggressive, nonnative pasture species (e.g., smooth brome, *Bromus inermis;* perennial ryegrass, *Lolium perenne*) that may compete with intentionally planted species.

Figure A-1. Straw is used as a mulch and in sediment logs to control erosion. Here, sediment logs (or wattles) are shown staked around a culvert (photo courtesy of Joe DiVittorio, 2011).

When hay is used as an animal feed, such with recreational riding and pack stock, use a certified weed-free hay. For more information on these topics, refer to the North American Weed Management Association's Web site: http://www.nawma.org/index.html. Since many Reclamation lands are often adjacent to other Federal and State administered lands, these lands frequently enforce weed-free policies or statutes.

Equipment and Work Sites

Equipment used at certain worksites may demand more, or sometimes less, stringent inspection attention than at other worksites, depending on site-specific conditions. Consider the following scenarios as examples:

- **Scenario 1.** Since most weed plant fragments and seeds are found in the topsoil, when working in a barrow site where no topsoil is left, and only subsoil or gravel remains, it would be less likely that vehicle movement out of such an area would be contributing greatly to the spread of weed plant species (figure A-2).

- **Scenario 2.** If equipment is used at a location known to be infested with a high risk invasive species, the equipment should undergo vigorous inspection, followed by thorough cleaning, and a final inspection before being moved off the worksite. At the new worksite location, the

equipment should be inspected again, preferably by someone other than the original inspector before the equipment is placed into service. This situation would be especially true for watercraft or in-water equipment previously used in zebra or quagga mussel infested waters.

Figure A-2. Fill materials separated by type – soil, broken concrete, pavements, etc. – temporarily stored at a barrow site (photo courtesy of Joe Divittorio, 2010).

- **Scenario 3.** Even with carefully inspected and cleaned equipment, imported fill material (such as rock, soil, broken concrete, and gravel) needed during certain types of construction and maintenance work may become the source of foreign species infestation, rather than the equipment. Keep the following points in mind:

    - Fill materials obtained in close locality to the work site would usually have a lower potential to introduce a foreign species, compared to materials brought in from more distant locations.

    - It may be possible to select barrow locations that have been determined through inspection to have low risk for harboring foreign species.

    - Certain fill materials that are processed away from the work site, such as washed crushed rock and gravel, can reduce the potential of foreign species transfer.

    - Recycled fill materials, such as broken concrete and pavements, often have adhering residue soils that can harbor foreign species. Prior to transport to the work site, reduce the risk of transporting foreign

species by having these materials cleaned at an off-work site location (figure A-3).

- Stockpiled fill materials suspected of harboring foreign species at the work site may be covered by black plastic and enclosed by silt fencing to help control their spread (figure A-4).

Figure A-3. Stockpiled broken concrete – note contact surfaces with adhering residue soils. These surfaces can harbor foreign species from the site of previous use (photo courtesy of Joe DiVittorio, 2010).

Figure A-4. Stockpiled fill material at a construction site enclosed by silt fencing to help control soil loss and the potential spread of foreign species. Black plastic covering (seen in upper right corner) has been pulled back to allow machine work (photo courtesy of Joe DiVittorio, 2010).

The above scenarios are highly situational, as will be the decisions to be made by the individual in actual field locations. Careful review of the potential for spread should be left up to knowledgeable personnel, and the level of inspection, as well as the location of inspection staging areas, should be determined on a case by case basis. It is possible that when moving between nearby sites that are infested with the same invasive species, inspections may not be necessary until leaving the final site.

Inspection Protocols for Personal Gear

What to Look For

Seeds, plant material, soil, mud, insects, and other invertebrates.

Snails, mussels, algae, aquatic plant fragments, and other aquatic species.

For in-water equipment, inspect for zebra and quagga mussel infestations. Look for adult mussels and feel by hand for very small juvenile mussels (an immature life stage) attached to anything that has made contact with raw water.

Clothing, hats, socks, shoes, gloves, and jackets should be thoroughly inspected for above-listed materials. Pockets should be turned inside out to remove debris. Shoelaces and shoe tongues should be checked.

Upon inspection, preclean personal gear by physical removal of contaminated material with a stiff brush, lint remover, compressed air, or pressurized hot water.

Note: Some of the information in the following lists has been adapted from the *Plant Dispersal Information System* (U.S. Army Corps of Engineers - Engineer Research and Development Center, 2006) and the 100th Meridian Web site (100th Meridian Initiative, 2011).

Specific Areas of Concern

Particular attention must be given to places where foreign material could become accidentally trapped, such as in the cuffs and folds of clothing, treads of boots or waders, or closures such as zippers or ties.

Closures:

Zippers, belts, laces or ties, buckles, straps, Velcro grips, buttons and fasteners, rivets

Loose Particle Fabric:

Canvas, nylon, cotton, poly blend, wool, fleece, netting, suede

Other:

Socks and ankle grips, treads of footwear, cuffs and folds, seams, flaps, pockets, collars and hoods, ventilation openings

For more information, consult your State's Fish and Wildlife agency, as well as the 100th Meridian Web site: http://www.100thmeridian.org/.

Inspection Protocols for Watercraft and Facility Equipment

Watercraft and trailers are probably major contributors to the spread of invasive aquatic plants and animals (figures A-5 and A-6). New infestations of exotic aquatic plants and animals are often first discovered near boat ramps. Detailed inspections must be made before watercraft, trailers, and facility equipment in contact with raw water are moved from one water body to another.

Zebra mussels and quagga mussels are a complex inspection problem. Plant material is likely to be visually identified; however, the mussel juvenile (an immature life stage) can attach to watercraft hulls, trailers, anchor ropes, and anything else that contacts an infested water body without being visually identified. Since the juvenile is microscopic and cannot be seen without laboratory equipment, do not rely on visual inspection alone. Juvenile mussels can attach to a surface when they are ~~"a~~s small as a sesame seed"; therefore, they are detectable only by feeling by hand along all surfaces and inside holes and crevices. On a smooth surface, juvenile mussels will feel gritty, like sandpaper. As the juvenile ages and grows, it may become visible to the unaided eye, appearing as a nondescript speck. Equipment that has been in water for a long period of time can become infested with adult mussels (figure A-7).

Remember:

- Zebra and quagga mussel inspections can be an involved and complex process.
- The life stage of the mussel will influence inspections; adult mussels can be seen, juvenile mussels must be detected by feel.
- If you are not familiar with the life cycle of these mussels, refer to appendix C, pages C-103 through C-111 for more information.

A guidance video presentation produced by the Pacific States Marine Fisheries Commission, in conjunction with the Washington Department of Fish and Wildlife and the U.S. Fish and Wildlife Service, entitled, "~~D~~on't Move a Mussel!" http://www.aquaticnuisance.org/video presents methods to inspect watercraft for mussels. The following is a synopsis of material presented in the video (Pacific States Marine Fisheries Commission, 2008).

Figure A-5. It is possible for mussel juveniles and adults to attach to aquatic weeds; this photo shows aquatic weeds (macrophytes) caught on a boat trailer at a Lake St. Clair boat access.

Figure A-6. Mussels on the lower unit of an inboard/outboard engine.

Figure A-7. Adult quagga mussels can be seen covering a rope used in the Lower Colorado River. More than likely, this rope also has unseen juvenile life stage mussels as well (photo courtesy of Joe DiVittorio, 2008).

Amphibious or Water Vehicles

Follow the same protocol shown in the video "Don't Move a Mussel!"

Inspect bilge compartments, raw water holding tanks such as ballast water tanks, wet and live wells, propellers, trailers, anchors, chains, ropes and ties, tread mats, and traction grids.

General Considerations:

- **LOOK** for attached adult mussels on all surfaces.
- **FEEL** by hand for attached juvenile mussels on all surfaces.
- **CHECK** all components, such as the hull, in live wells, motor, axle, dock line, trailer lights, rollers, runners, and any other parts in contact with water.

Outboard Engine Watercraft Look especially at the bottom drain holes, propeller, cooling water intake ports, and motor mounts.

Inboard/Outboard Engine Watercraft Look especially at propeller, steering components, cooling water intake ports, and under trim tabs.

Inboard Engine Watercraft

Look especially at trim tab, rudder, crevices, water intake ports, propeller, and input cap.

All Watercraft Engines

If the watercraft engine is not a closed cooling system configuration (if the engine intakes its cooling water from the environment), the following applies. Although it may seem counterintuitive, it is possible for zebra and quagga mussels to live inside the cooling system of watercraft engines and become a source of contamination when it is operated in un-infested waters. Mussel veligers can enter the engine cooling system through the cooling water intake, become attached inside the system, and grow into the adult (reproductive) life stage mussels. The mussels can survive on the ~~–c~~ool" side of the cooling system—that portion of the cooling system beginning at the water intake ports flowing to the engine's water jacket (heat exchanger)—for the long term in between uses (figures A-8 and A-9).

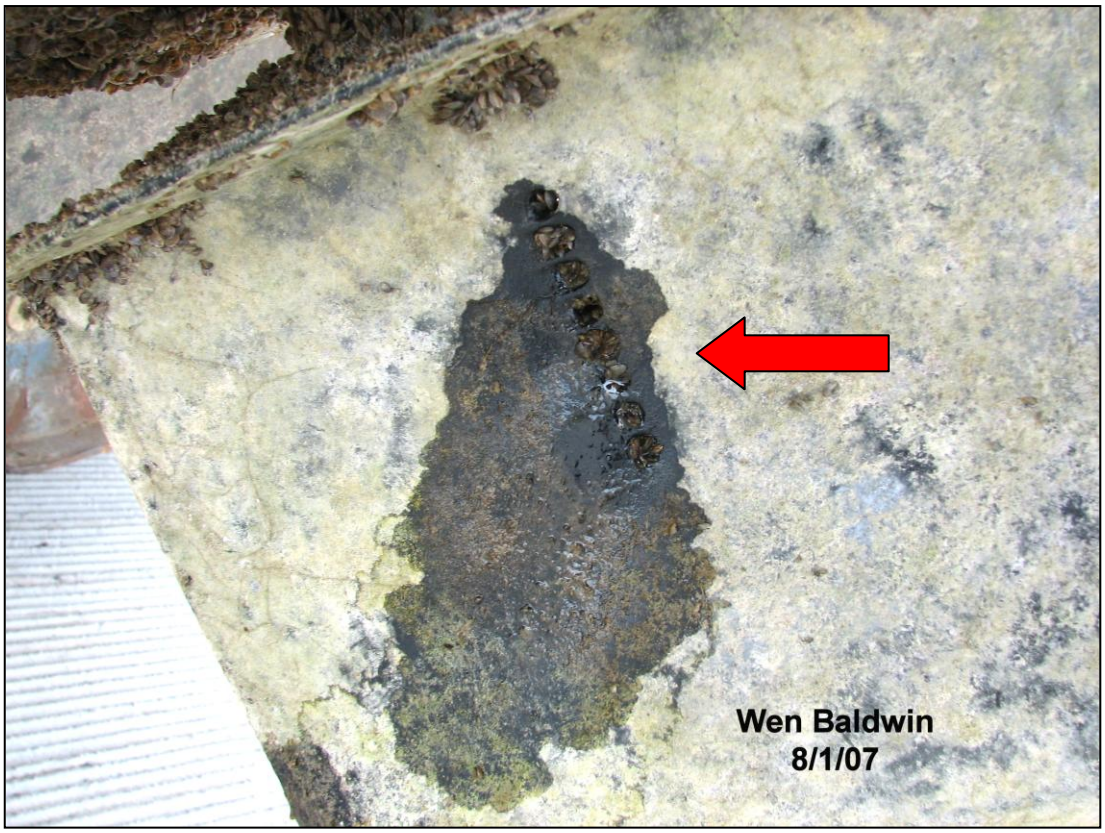


Figure A-8. Closeup view of outboard motor shaft housing. Adult quagga mussels living inside the engine and plugging the water intake ports of this outboard motor.

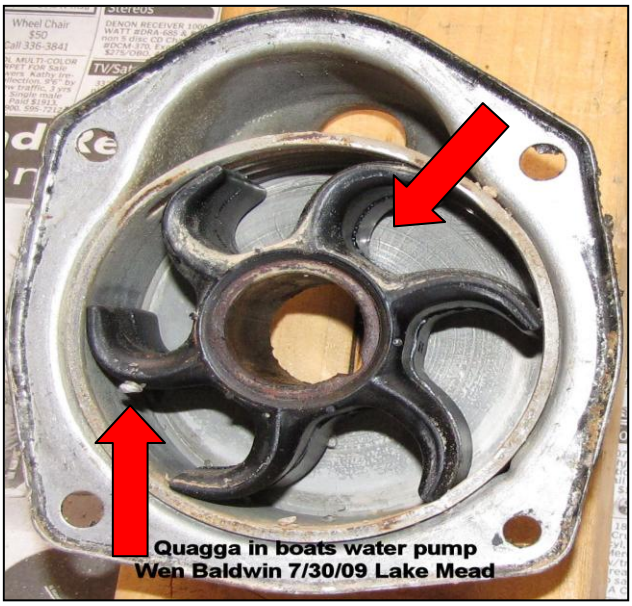


Figure A-9. Adult quagga mussels found living inside a disassembled watercraft engine water pump.

At the water jacket, engine heat is transferred to the cooling water. Now heated to at least 140 °F, the circulating cooling water is on the ~~h~~ot" side of the cooling system—from the water jacket to the water outlet ports—where the heated cooling water will kill any mussels present (figure A-10). See appendix B for specific decontamination procedures for watercraft engines.

The Colorado Department of Water Resources *Aquatic Nuisance Species (ANS) Watercraft Inspection Handbook* contains a High-Risk Inspection Form for use on high-risk trailered watercraft (Colorado Department of Water Resources, 2009). It can be accessed at: http://www.parks.state.co.us/NaturalResources/ParksResourceStewardship/AquaticNuisanceSpecies/Pages/AquaticNuisanceSpeciesHome.aspx

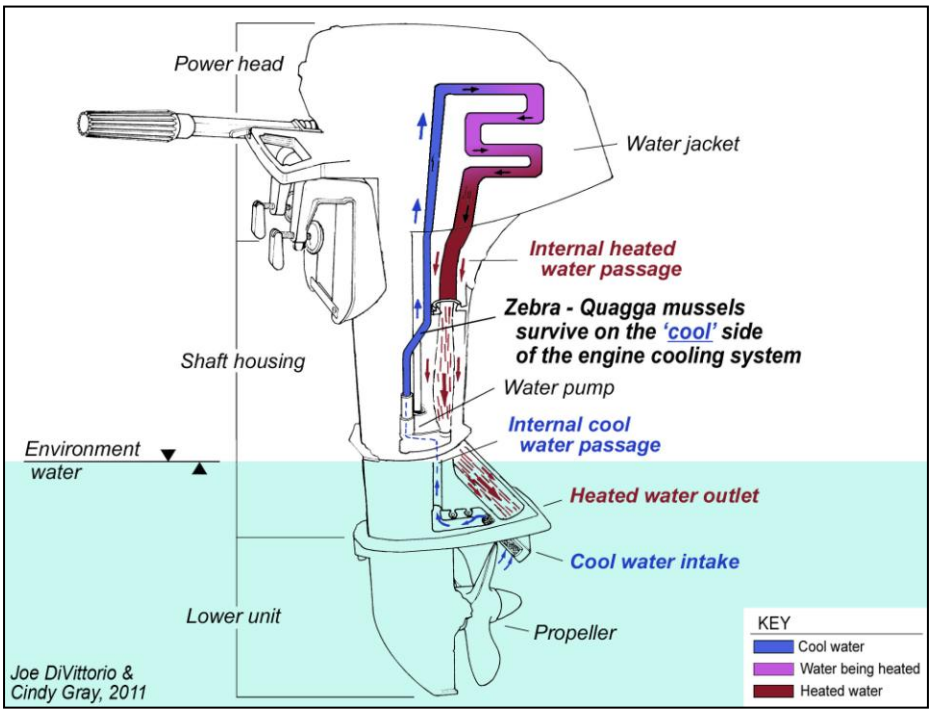


Figure A-10. Simplified cooling system of an outboard motor (courtesy of Joe DiVittorio and Cindy Gray, 2011).

Facility Equipment, Water Bags Used for Crane Testing, and In-Water Construction and Maintenance Equipment

Inspect facility equipment (figure A-11) and in-water construction equipment (figure A-12) in much the same way watercraft would be inspected. Figure A-12 shows water weight™ bag testing on an in-water barge. Note that both the water bags and the barge itself may be contaminated during use. Be sure to inspect all equipment that comes into contact with raw water. Any equipment item that has been in contact with raw water has the potential to become the source of contamination if it is placed into service at a new location. Remember that both adult and veliger life stages of mussels can hide in inconspicuous equipment recesses. A thorough inspection is necessary using the following points:

- If equipment is used at a location known to be infested with an invasive species, the equipment should undergo a preinspection, followed by thorough cleaning and a postcleaning inspection, before being moved off the worksite.

- At the new location, the equipment should be inspected again, preferably by someone other than the original inspector before the equipment is placed into service.

- If, on reinspection, contamination is found on the equipment, do not allow the equipment entry on the new worksite; either return the equipment to the location of last use for additional cleaning or arrange for cleaning at a location that is specifically designed for equipment cleaning.

Figure A-11. Mussels covering a penstock gate at Davis Dam (photo courtesy of Dave Arend, 2008).

Return to Inspection-Cleaning Flowchart

Water bags used for crane testing generally cannot be easily inspected at the level required to find the mussel veliger life stage. Therefore, rather than inspecting it, if the water bag was filled with raw water during its prior use and was not decontaminated, assume it is contaminated. See appendix B for more information regarding water bag decontamination procedures. If the crane testing company can provide certification that the water bag was filled only with potable water at its last location, or was filled with raw water and properly decontaminated, the bag can be assumed to be free of contamination. However, if there is any doubt, insist upon decontamination of the water bag before allowing its use at the facility.

Figure A-12. The 'Betty L' Barge Crane, Morrison Knudsen Company, during water weight bag™ testing, Baltimore, Maryland (photo courtesy of Jim Jota, Imes, Inc., 1994).

Mechanical clearing of aquatic vegetation from the inside embankments of water conveyance systems such as canals and open laterals (figure A-13) is a common maintenance practice. It is often used in combination with other integrated pest management tools to combat aquatic pest and invasive plant species.

Aquatic vegetation can restrict the flow of water in water conveyance systems. The seasonal buildup of this vegetation reduces water delivery, increases channel sedimentation, and increases hydraulic pressures on embankments from flow damming. In drainage systems, aquatic vegetation can inhibit the return flow of water from irrigated fields.

These species can be spread to new locales by contaminated equipment. In addition to the possible spread of aquatic vegetation from contaminated equipment, many invasive animal species, such as zebra and quagga mussels, can attach to aquatic vegetation and be inadvertently transferred onto equipment. Lacking inspection and decontamination, both invasive plant and animal species can be moved to the next equipment use location.

Determine if a bulk commercial composting facility will accept the removed vegetation; otherwise dispose upland well away from waterways. Inspect all waterway maintenance equipment in much the same way watercraft, or rubber-tired and tracked vehicles would be inspected. Look for any vegetation, soil, mud or water held in or on equipment after use. Follow the **Clean, Drain, and Dry** decontamination procedures detailed in appendix B.

Figure A-13. Equipment can become contaminated with pest and invasive species during field work. Contaminated equipment can spread these species to uninfested sites. Inspect and clean equipment before moving to a new work location.

Inspection Protocols for Rubber-Tired and Tracked Vehicles

The following is a suggested inspection protocol for vehicles that have been exposed to invasive weed material. In the field, all vehicles should be inspected and all visible material should be removed.

Specific Areas of Concern

Particular attention must be given to places where foreign material could become accidentally trapped, such as in cracks and crevices, in undercarriages, and in the treads of tracks or tires (figure A-14). The following is a list of areas that warrant special attention and where plant material could most easily become lodged.

Backgrounder!

Click here (or see page A-25) to learn more about how animals might play a role in spreading weeds and invasive plants.

Note: The following has been excerpted from the Plant Dispersal Information System, Version 1 (U.S. Army Corps of Engineers – Engineer Research and Development Center, 2006).

Figure A-14. A packrat nest constructed around the disk brake inside the front wheel of a vehicle. The major nest building material is straw, which was being used as a soil erosion control treatment at a nearby construction site (photo courtesy of Joe DiVittorio, 2011).

Drawings and/or photos of specific types of vehicles are provided on the following pages.

Rubber Tired Land Vehicles (see "Typical Rubber Tired Land Vehicle" detail)

- Crevices in upper surface and panels
- Tires, rims, and fender wells
- Spare tire mounting area
- Bumpers
- Front and rear quarter panels
- Around and behind grills
- Bottom of radiator vent openings
- Brake mechanisms
- Transmission
- Stabilizer bar
- Shock absorbers
- Front and rear axles
- Beds
- Suspension units
- Exhaust systems
- Light casings and mirrors

Tracked Land Vehicles (see "Typical Tracked Land Vehicle" detail)

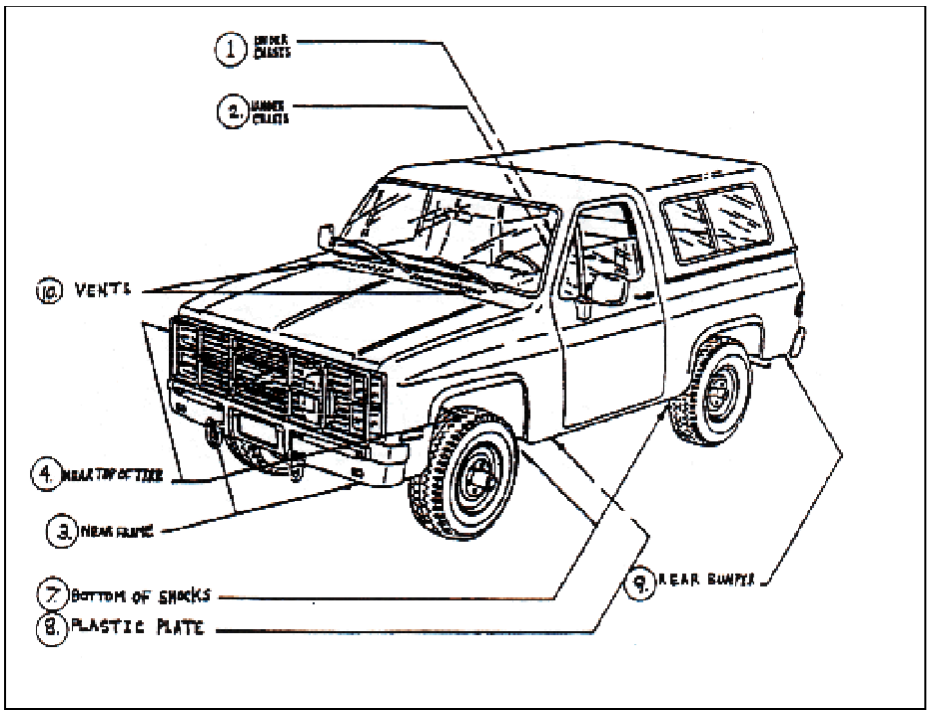
- Crevices in upper surface and panels
- Top of axles and tensioners
- Support rollers
- Between rubber or gridded areas
- Beneath fenders
- Hatches
- Under casings
- Grills

Interiors of All Vehicles

- Beneath seats
- Beneath floor mats
- Upholstery
- Beneath foot pedals
- Inside folds of gear shift cover

The Armed Forces Pest Management Board publication Technical Guide-31 (U.S. Department of Defense, 2004) offers some useful guidelines and considerations for inspecting vehicles. The following illustrations are taken from that guide. It can be accessed at the following Web site: http://www.afpmb.org/pubs/tims/tg31/tg31.pdf

Typical Rubber Tired Land Vehicle



Problem Areas

1. Fuel tank filler tube where it enters the vehicle body.

2. On top of the fuel tank protector.

3. Shackles on stabilizer bar.

4. Top of the front brake calipers.

5. Inside the cab, underneath the edge of the floor mats and the spare tire area.

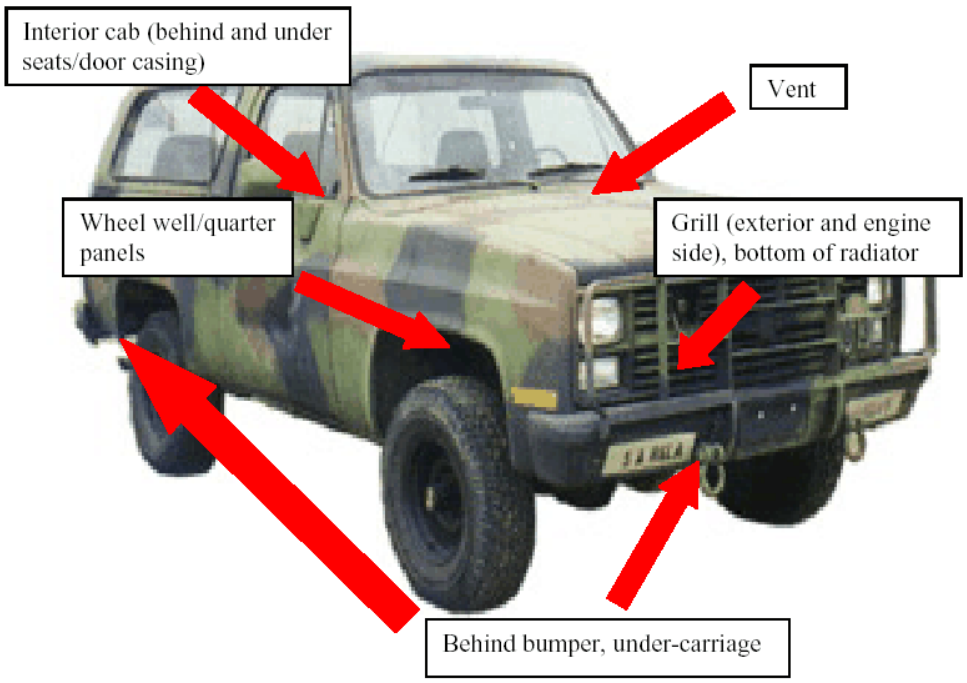
6. On top of the transmission.

7. Bottom of the shock absorbers where they join the axles.

8. Above the plastic protective plate behind the vehicle‘s front tires.

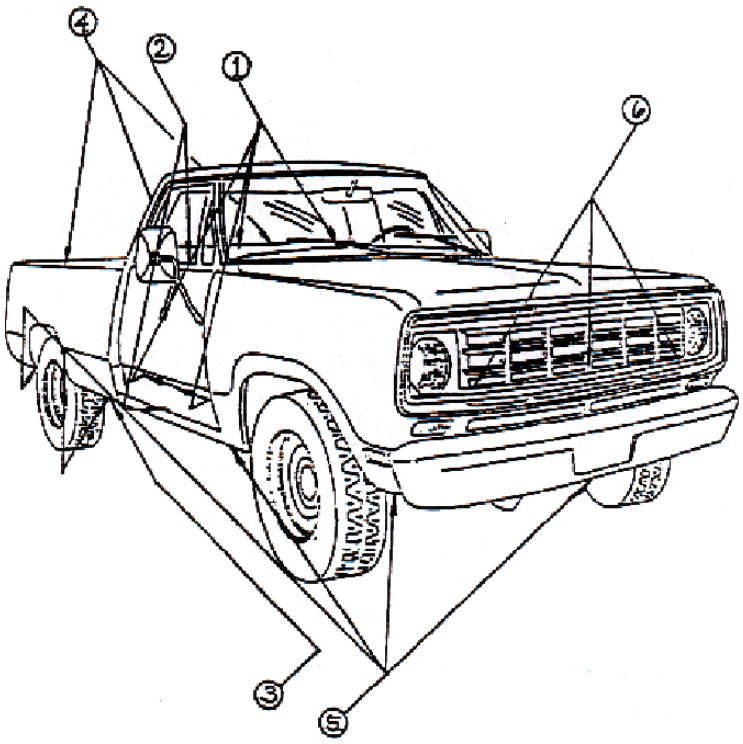
9. Rear bumper area (electrical wiring and tail lights).

10. Hood vents.



Problem Areas

1. Inside the cab, underneath the vehicle floor mat edge.



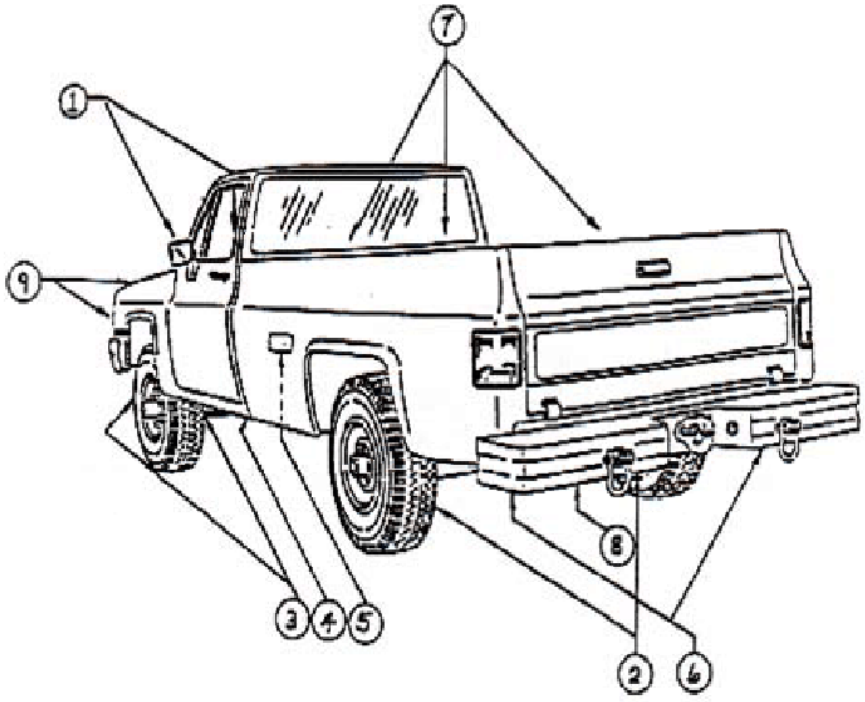
2. Underneath the seat.

3. On top of the rim of the spare tire.

4. The rear bed.

5. Ledges underneath the bumpers, front and rear quarter panels.

6. Front of the grill and tray under the radiator.



Problem Areas

1. Twigs and/or debris in vent openings.

2. Between the rear wheel brake drums and the steel rim of the wheel.

3. On top of the front suspension components.

4. On top of the transmission.

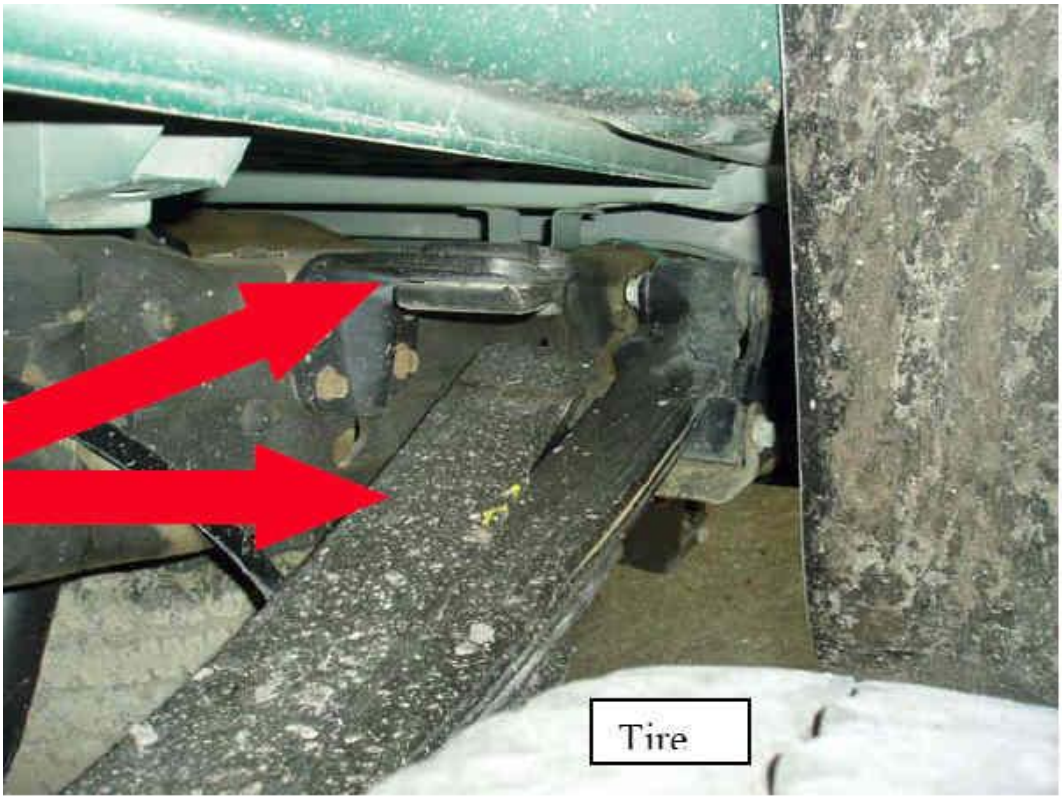
5. At the bend of the fuel inlet tube, just before it comes in contact with the body of the vehicle; view it from underneath.

6. Rear bumper area, especially behind the U-shaped protective plate that protects tail light electrical wiring.

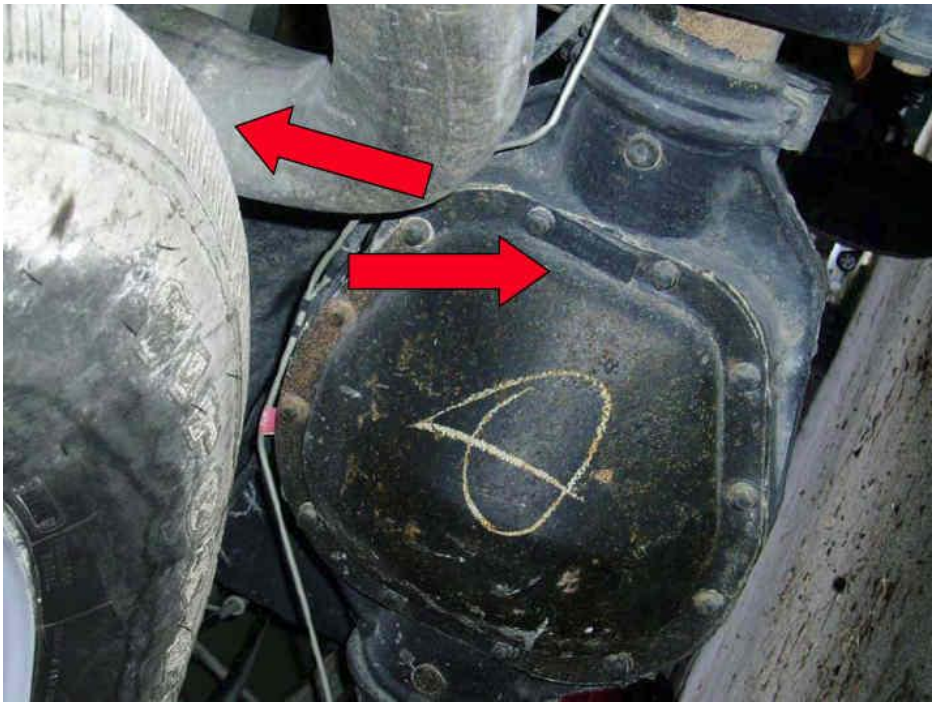
7. Twigs and/or debris in bed of vehicle.

8. On top of the rim of the spare tire.

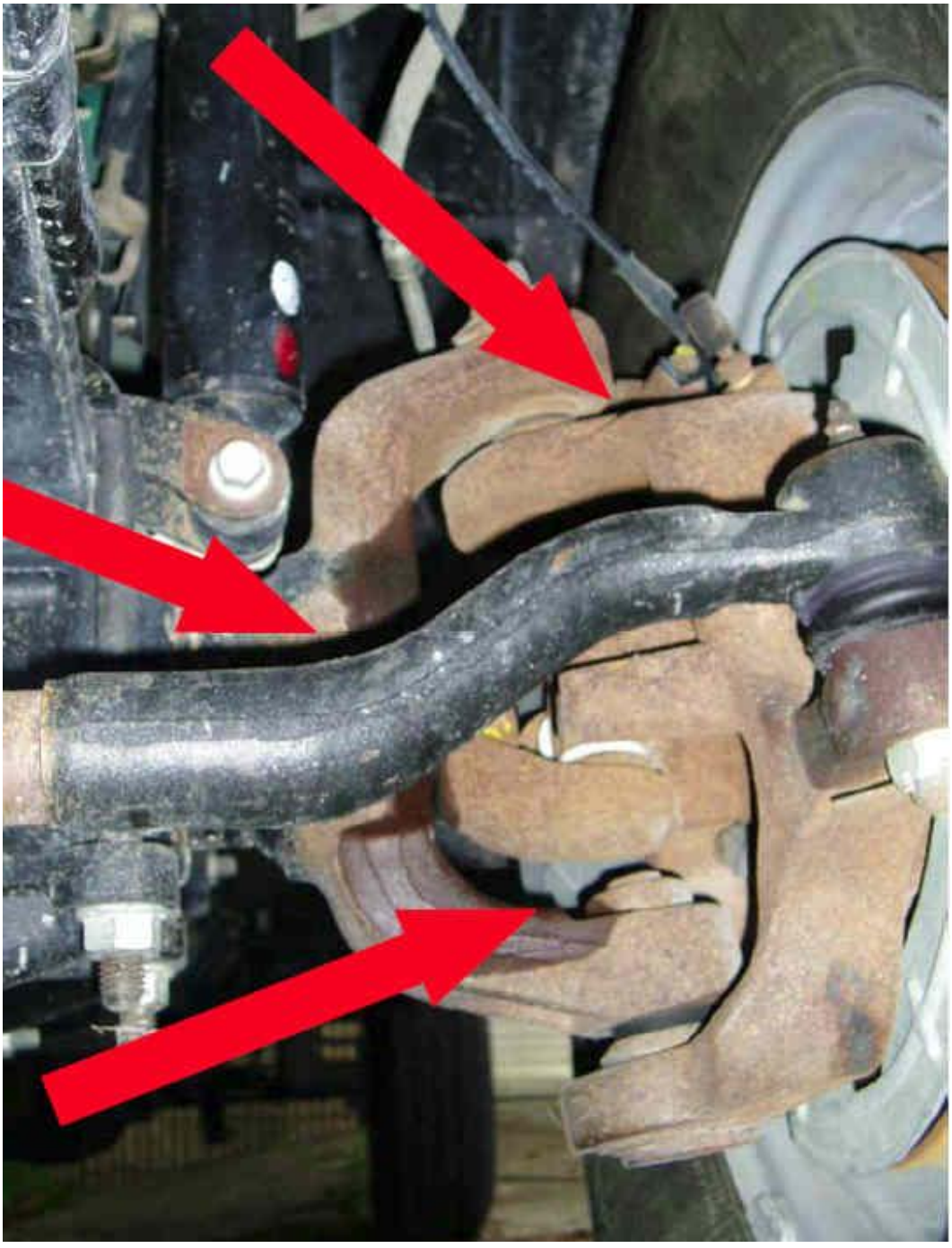
9. Front area of the grill.



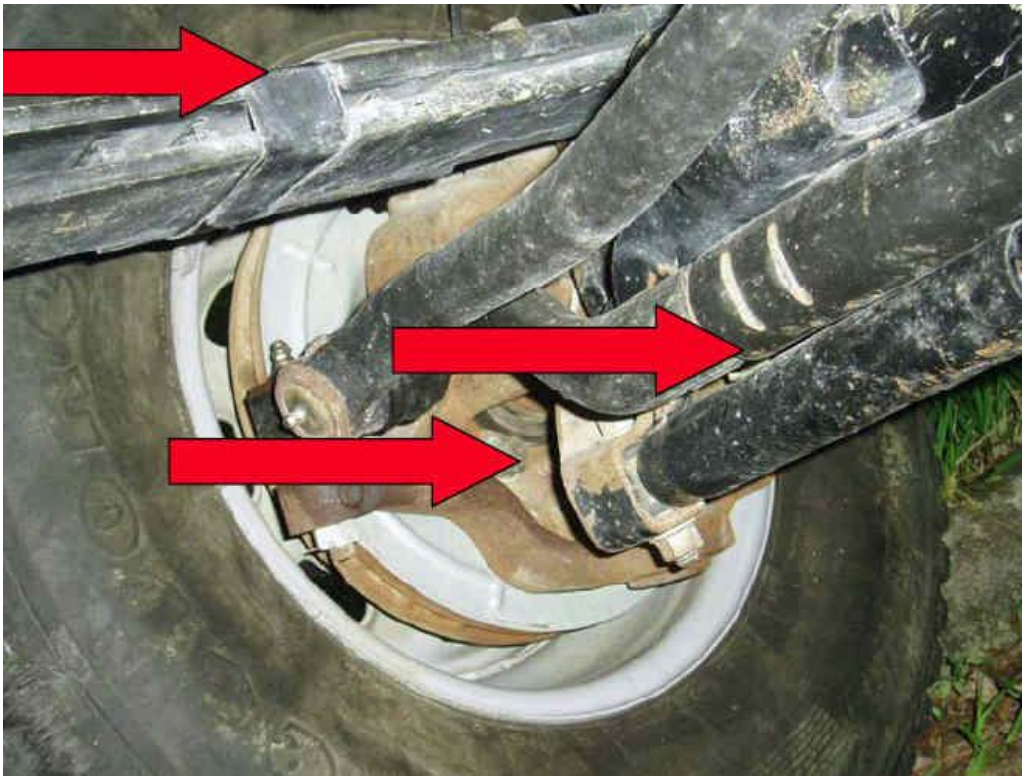
Wheel well of a pickup



Rear differential (undercarriage) and spare tire



Front wheel, spindle and kingpin

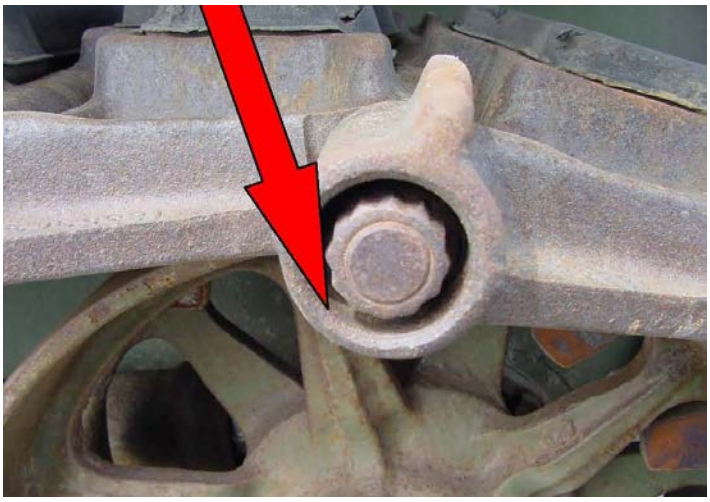


Front spindle and steering cross tube

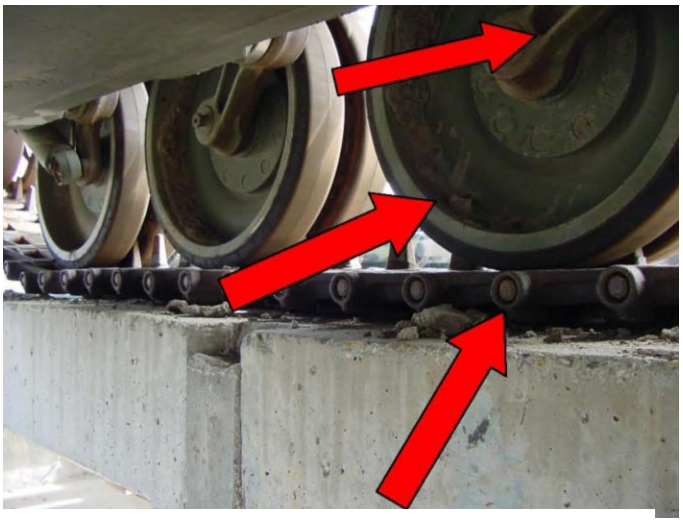
Cowl under windshield and all engine compartment components

Typical Tracked Land Vehicle

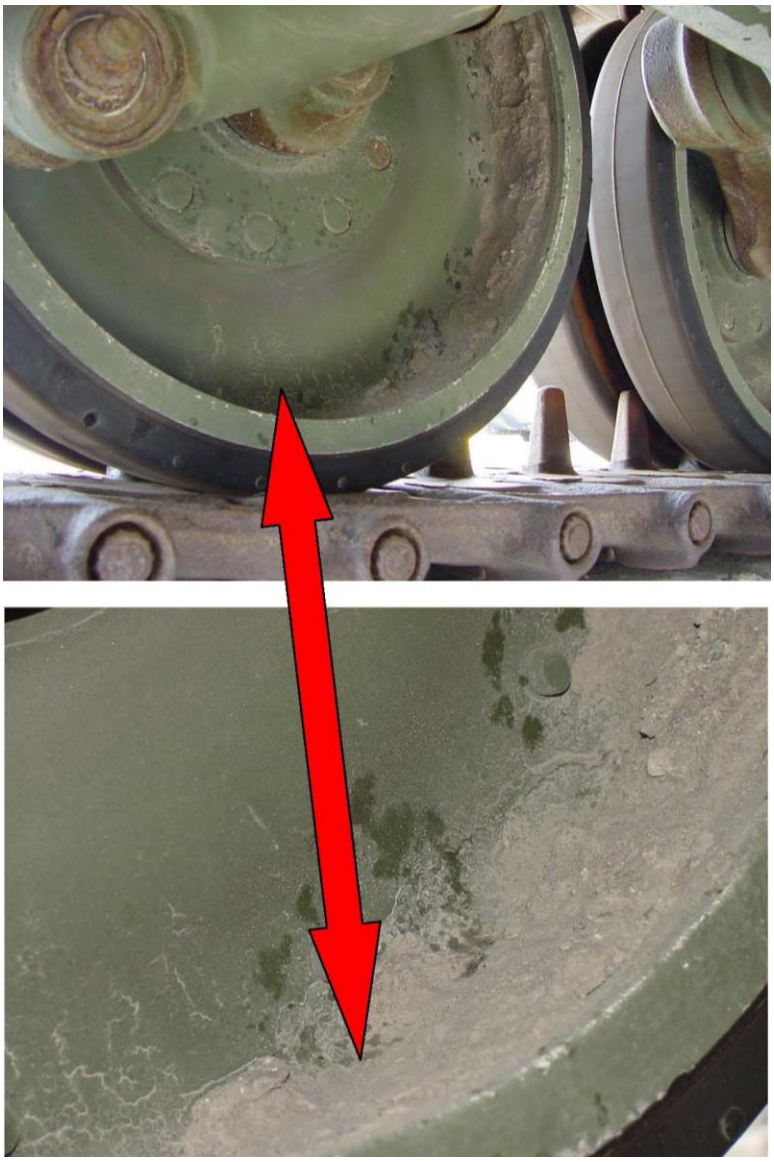
All tracked land vehicles share many common components such as tracks, rollers, idlers, tensioners, and sprockets.



Typical track plate link pin



Inner view of track roller, roller support, and track.



Inner view of track roller. Postcleaning inspection on a previously cleaned vehicle noted remaining mud accumulation. This photo illustrates the value of an equipment postcleaning inspection.

Backgrounder!

Animals Spread Weeds and Invasive Plants

The packrat, also known as the wood rat or the trade rat, is a prolific nest builder. Figure A-14, shown previously, provides a remarkable example of the locations a packrat will select for nest building. Plant material is generally a major building component for packrat nests, and this photo illustrates that animals can play a role in distribution of plant species. The rat will search the surrounding area, harvest and ~~–p~~ack" many species of local plants, including any available weeds and invasive plant species for nest building in or on equipment. Equipment transporting a packrat nest over a great distance, is also inadvertently transporting a mass of potentially weedy and invasive plants, containing both seeds and plant fragments that are capable of spreading. The material used in this particular packrat nest consists of packrat-harvested grasses, various other plants and chewed-to-size woody twigs. The major nest building material was straw being used as a soil erosion control treatment at a nearby construction site.

Generally, nest building may take place in or on equipment located at construction sites, industrial yards, or other areas near rural and semirural settings. The packrat will seek out a nesting site on equipment, preferring close contact in irregular, multi-surfaced hidden points on equipment of all kinds. Recently idled and seldom used equipment provide a quite nest building opportunity for the packrat. Packrat nests can be found on engine tops along the firewall, next to exhaust components, along frame rails, and on top of fuel tanks and skid plates.

Equipment inspectors should be watchful of packrat activity that include not only seeing the packrat itself, but also rat scat, unexplained equipment damage to wiring and soft parts, packrat rub spots on equipment that may leave hair or a sheen on surfaces. Packrats are also attracted to small shiny objects, and they will take these items from open toolboxes and accessible equipment cockpits.

Incidentally, damage to equipment can be both extensive and expensive because the packrat will chew on electrical wiring, and rubber and plastic parts for nest building material. Nests built near equipment exhaust components create a fire hazard. In the situation depicted in figure A-14, chewing damage to the brake system hose and the wheel speed sensor electrical connector is likely. This vehicle was reported to police as a possible safety issue.

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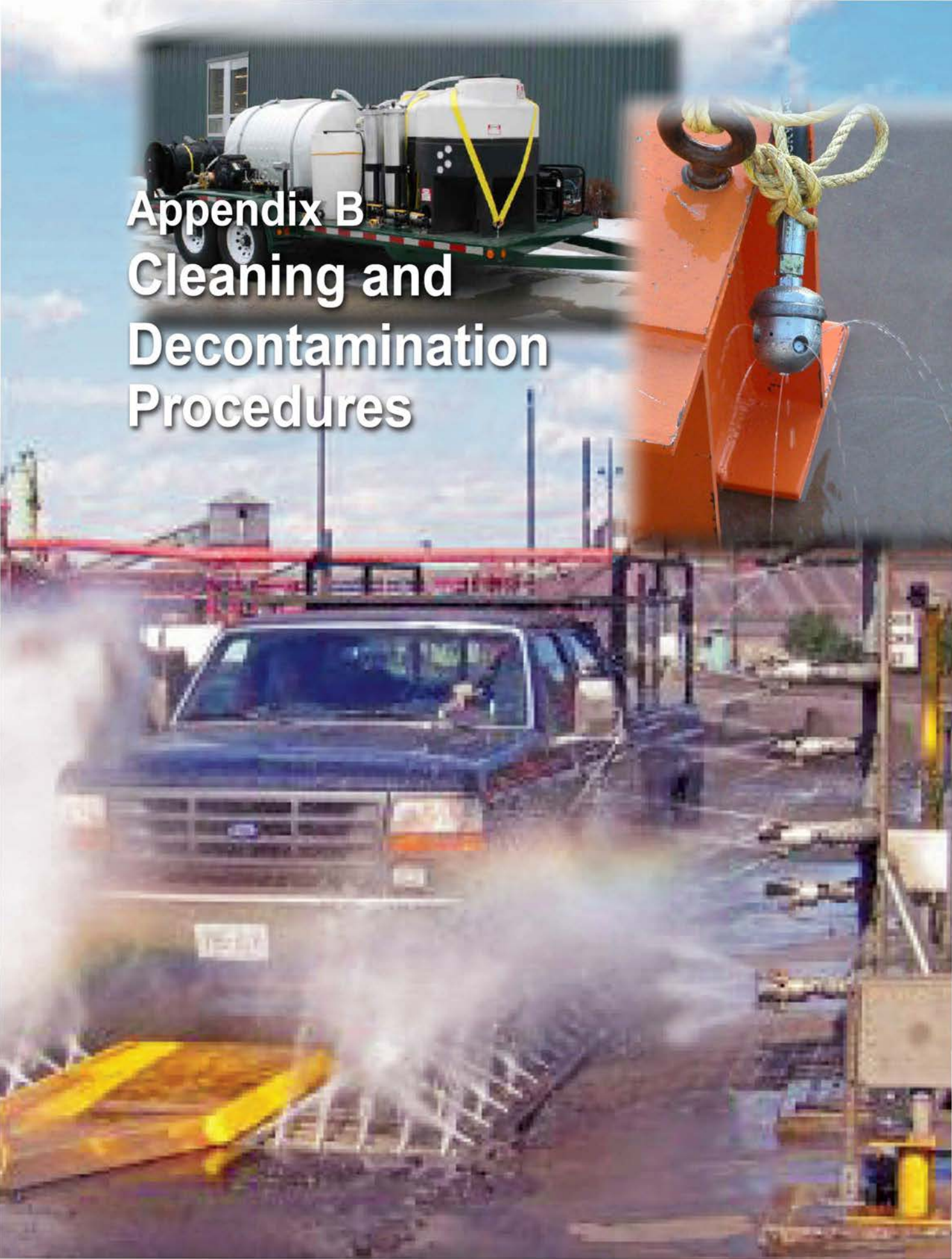

Appendix B
Cleaning and Decontamination Procedures

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Appendix B

Cleaning and Decontamination Procedures

Prior to conducting a cleaning or decontamination action, be sure to review the "Overview of Inspection Procedures" and the "Overview of Cleaning Procedures" sections, and appendix A.

Note: Some of the following procedures have been adapted from the *Plant Dispersal Information System*, V.1.0 (U.S. Army Corps of Engineers – Engineer Research and Development Center, 2006).

Cleaning and Decontaminating Personal Gear

Precleaning Methods

Brushing (Physical Removal)

Used in conjunction with another physical removal method, such as vacuuming, or when in the field, this method is considered to be moderately effective in removing the majority of plant material from clothing, footwear, or other personnel gear. The use of a brush will remove most surface soil, plant material, and foreign matter from clothing. If there is a nap, brush with the nap rather than against it. Brushing against the nap could further embed small seeds into the weave of fabric. A combination of soft and stiff bristles of varying length is recommended for footwear and tread, while medium length and stiffness is desired for removal of soil and other matter from clothing. Follow up with a water wash or as recommended by the manufacturer.

Vacuuming (Physical Removal)

Vacuuming the article of clothing with a brush attachment is suggested to remove most loose particle matter, but care should be given, as small seed may become embedded in materials. To prevent contained plant and soil matter from being redeposited or redispersed following the cleaning process, collected matter should be double bagged and disposed of in a sanitary landfill. Follow up with a water wash or as recommended by the manufacturer.

Use of Adhesive Roller (Physical Removal) in Conjunction with Other Physical Removal Technique

Used in conjunction with other physical removal methods, such as brushing or vacuuming, or when in the field, this method is considered to be moderately effective in removing the majority of plant material from clothing, equipment, and gear. Proper attention and care given during removal is a direct reflection of the

Return to Inspection-Cleaning Flowchart

potential efficiency of this technique. Seed and fragment materials readily attach to the adhesive sheets and are effectively lifted out of seams and the weave of loose particle fabrics. Roller sheets should be double bagged and disposed of in a sanitary landfill.

Water Washing in Conjunction with Physical Removal Technique

General water washing, or other cleaning methods as recommended by the manufacturer, can be used in conjunction with a physical removal technique such as brushing or vacuuming and is moderately effective in removing residual foreign materials, although small and embedded seeds are capable of persisting. In addition, seed may remain viable following a wash treatment. In extreme situations, where known invasive materials are present, wastewater can be treated or filtered, and the waste materials double bagged and disposed of in a sanitary landfill.

Thermal Treatment

Thermal treatments involve the use of extremely hot temperatures in order to kill all invasive material. Applying steam, hot air, or hot water has proven to be especially effective.

Disadvantages to the use of thermal treatments, such as steam and hot water, are the apparent risk of burns, its labor-intensive nature, and the initial investment cost of equipment. PPE required.

Cleaning and Decontaminating Vehicles and Equipment

Precleaning Methods

Brushing (Physical Removal)

Used in conjunction with another physical removal method such as vacuuming, or when in the field, this method is moderately effective in removing the majority of plant material from equipment and gear. Brushing will remove most surface soil, plant material, and foreign matter. If there is a nap to fabric, such as upholstery or carpeting, brush with the nap rather than against it. Brushing against the nap could further embed small seeds into the material.

A combination of soft and stiff bristles of varying length is recommended for use on carpeting or components made of rubber, nylon, or plastic. Bristles of medium length and stiffness are desired for removal of soil and other matter from fabrics and upholstery. Stiff bristles are recommended for the tread of wheels that become encrusted with soil and mud. Metal bristles may also be used to remove

soil or concrete in treads, but heavier wear and tear to the equipment will result. High-pressure compressed air blasting may be used to assist soil removal.

Followup with vacuuming, high-pressure air blasting, or high-pressure wash is recommended as applicable.

Vacuuming (Physical Removal)

Vacuuming equipment with a brush attachment is suggested to remove most loose particle matter, but care should be taken because small seed may become further embedded in materials. To prevent contained plant and soil matter from being redeposited or redispersed following the cleaning process, collected matter should be double bagged and disposed of in a sanitary landfill. Followup with water washing, high-pressure air blasting, or high-pressure wash is recommended as applicable.

Water Washing with High-Pressure Wash and With or Without Thermal Treatment

General water washing with high-pressure wash or thermal treatment is the most effective method for removing residual foreign materials, although small and embedded seeds are capable of persisting. Where known invasive materials are present, wastewater can be treated or filtered, and the waste materials double bagged and disposed of in a sanitary landfill.

High-Pressure Wash

Improvement in the design of high-pressure washing makes it the most effective means of cleaning heavily soiled and contaminated items. Not all items are capable of withstanding the pressure of this treatment, and it should only be used where applicable.

There are many models of high-pressure washers, from simple hand-held nozzles to laser guided, robotic control systems. In some cases, containment and operation sheds are portable. The water systems can be fresh or recycled and use hot or cold water. PPE required.

Thermal Treatment

Thermal treatments involve the use of extremely hot temperatures in order to kill all invasive material. Applying steam, hot air, or hot water has proven to be especially effective.

Disadvantages to the use of thermal treatments, such as steam and hot water, are the apparent risk of burns, its labor-intensive nature, and the initial investment cost of equipment. PPE required.

Selecting a Washdown Location

The U.S. Department of Defense Armed Forces Pest Management Board Technical Guide 31 (Department of Defense, 2004) presents criteria regarding the location and equipment to be used for washing land vehicles.

To avoid reaccumulation of soil on cleaned vehicles, the Department of Defense recommends supplying a paved area for washing, offloading, and staging vehicle cleaning operations, with paved roads between. This type of facility will often not be a viable option for activities in remote areas. Elevating the washing areas (see figure 15 under "Overview of Inspection Procedures") enables cleaning personnel to access the underside of vehicles and equipment, where contaminants are otherwise difficult to reach.

Water runoff carrying soil, seeds, animals, and petroleum contaminants must be managed with the use of berms or other containment (figures B-1 and B-2). Silt fence installed along perimeters of work areas can also aid in preventing spread of contaminated materials outside of the washdown location.

Figure B-1. Bermed portable mat system with sump pump for water recycling (U.S. Department of Agriculture, Forest Service site).

Best Management Practice:

Do not locate the cleaning site adjacent to storm water drains that allow untreated effluent to enter surface water bodies.

The area must be large enough to safely accommodate all vehicles and personnel before, during, and after cleaning operations. Considerations should include weather protection when necessary. An efficient site design should make it easy for vehicles to move into and out of the area (U.S. Department of Defense, 2004).

High-wall portable berm with wall supports in place. High-wall berms might offer better overflow protection when conducting equipment washing. Remove the wall supports on one side to move equipment onto the berm. All wall supports can be removed, and the entire berm rolled up for easy moving and storage. Bung openings can be positioned to fit specific need when ordering from the company (Interstate Products, Inc.).

Secured bungs are tied in place (Interstate Products, Inc.).

Figure B-2. Another example of portable mat systems (photo courtesy of Joe DiVittorio, 2003).

Water availability is another major consideration. Fresh water in a quantity suitable for all cleaning operations is necessary. When this is not possible, consideration should be given to other water options such as water recycling systems (figure B-1) or use of compressed air to remove soil. The benefit of compressed air is that there is no contaminated cleaning water to process.

Raw water, or even gray water, is sometimes used, but potential health issues may require precautions such as immunizations or specialized safety equipment for personnel (figure B-3). When pumping water from field sources, unintentional movement of exotic plants, problematic algae, or other invasive aquatic species must be addressed. Proper placement of pumps away from aquatic or shoreline vegetation that is known to be invasive is a prudent first step. Heating field source wat ile washing wi

Bureau of Reclamation

Figure B-3. Water for vehicle cleaning was pumped from conveyance channel at Socorro, New Mexico field site (Bureau of Reclamation photo).

Minimum water pressure for land vehicle cleaning should be at least 90 pounds per square inch (psi) (U.S. Department of Defense, 2004). Electricity or alternate power for pressure sprayers must be made available. Adequate hoses (with repair and spare supplies) should be on hand.

Water can be supplied as high volume and low pressure or low volume and high pressure. Each option has advantages and disadvantages based on specific cleaning needs and water availability. Heavy accumulations of soil and debris on large land-use equipment can best be cleaned using high volumes of water, but it may create water treatment or disposal issues. Still, some currently available cleaning systems can effectively remove large accumulations of soil with

relatively low-volume water delivery. Cleaning watercraft and other in-water equipment usually requires lower volume, high-pressure washing systems.

Water storage tanks, filters, and recapture systems can offer adequate onsite water supplies with less water use than would otherwise be necessary without recycling. By using sand or cartridge filters, many contaminated substances can be captured during cleaning operations to be safely handled later. In addition to soil and invasive species, wash water and used wash water filters may also contain oily residues from cleaning certain types of equipment. Such items may require handling, treatment, and disposal according to State and local standards.

Currently Available Systems

Some options that are available to paved surfaces and are currently in use by some agencies include portable runoff containment systems and elevated washracks. Geotextile cloth, rubber flexible mats with berms, and modular elevated washracks that can be moved into position with a forklift are also available. Some suppliers of currently available equipment for designing a washing system are listed in *Vehicle Cleaning Technology for Controlling the Spread of Noxious Weeds and Invasive Species* (Fleming, 2005).

The Forest Service has also built and field tested a portable vehicle washer mounted on a flatbed trailer (figure B-4). That system includes two high-pressure wands to wash sides of vehicles, an underbody high-pressure nozzle system, portable rubber mat system with side berms, settling tanks, and filtration system coupled with a 550-gallon holding tank, powered by a 5,000-watt gasoline generator. This portable system can wash at 800 psi, using 20 gallons of water per minute. Field tests demonstrated the ability to wash standard vehicles in 2 to 3 minutes. Further details about this portable vehicle washer can be found in *MTDC Portable Vehicle Washer* (U.S. Department of Agriculture, 2004).

InterClean Equipment offers several commercially available systems to wash and decontaminate vehicles and heavy equipment (figure B-5). The portable tire wash, "Red Wolf PT-15," can be installed at remote sites. Ground excavation, water supply, and 70-kilowatthour (460-volt) electrical service are required for this installation. Their HT series system includes chassis washing. More information on InterClean's vehicle washing and decontaminating systems is provided on their Web site: http://www.interclean.com/Default.htm (InterClean, 2011).

Figure B-4. Trailer-mounted washing system field tested by Forest Service for cleaning land use vehicles and other equipment (U.S. Department of Agriculture, Forest Service photo).

Figure B-5. InterClean Equipment's heavy duty washing system (InterClean, 2011).

Little Red Hen, LLC, is based in Bozeman, Montana, offers onsite services for vehicle and equipment washing (figure B-6), and has worked with the Forest Service on equipment cleaning projects. Further details about Little Red Hen, LLC, services are provided on their Web site: http://www.rrmobileservices.com/janda/inner.php?PageID=23 (Little Red Hen, 2011).

Figure B-6. Little Red Hen, LLC, Bozeman, Montana vehicle washing service. Filtered mud and debris are compacted and packaged for landfill.

General Considerations:

- Set up the best staging area possible for cleaning operations. A paved area with accommodations to elevate vehicles or otherwise allow easy access to the undersides of vehicles and equipment is the best setting. Otherwise, using geotextile access and exit areas, bermed water recovery areas, and portable vehicle lifts are the next best option.
- Equipment of all types should be cleaned at the location of last use. If this is not possible, arrange for cleaning at a facility that is specially designed for equipment cleaning.
- Preclean equipment that contains heavy accumulations by hand to reduce water demand.
- Make pressurized water available with pressure and nozzles capable of removing all soil and debris.
- Recapture invasive materials by using fine-mesh filters and dispose of invasives in a manner that ensures no spread. Do not allow wash waters to flow into storm drains because these drains often directly flow untreated into surface water bodies.
- At remote sites, install silt fence or otherwise contain materials left behind. Monitor sites closely and eradicate exotic species.
- Clean vehicles and equipment thoroughly, and ensure that they remain clean when leaving the site. Follow up cleaning operations with final inspections.
- Clean, drain, and dry all equipment.

Cleaning and Decontaminating in Zebra/Quagga Mussel Infested Areas

Note: Some of the following information has been adapted from the *Zebra Mussel Identification System* (U.S. Army Corps of Engineers – Engineer Research and Development Center, 2000) and from the 100th Meridian Initiative Web site (100th Meridian Initiative, 2011). Various other sources used in the preparation of this manual are listed in the Bibliography section of this appendix.

Remember:

- Zebra and quagga mussel cleaning operations can be an involved and complex process.
- The life stage of the mussel will influence cleaning actions.
- If you are not familiar with the life cycle of these mussels, refer to appendix C, pages C-103 through C-111 for more information.
- Chemical decontamination as a means to kill adult mussels may require as long as 10 days' contact time. Because of this resistance action, when associated with equipment, chemical solutions are usually better suited for veliger treatment.

Acceptable Decontamination Methods

Chemical Decontamination

The successful use of chemical decontamination depends on the mussel life stage, the kind of decontamination chemical, the chemical concentration used, and contact time. Since adult zebra and quagga mussels can close up and survive for extended periods of time under toxic external conditions, chemical decontamination as a means to kill adult mussels may require as long as 10 days' contact time. Because of this resistance action, when associated with equipment, chemical solutions are usually better suited for veliger (immature life stage) treatment. Decontamination chemicals are somewhat difficult to use, and successful results can be difficult to achieve. Generally, chemical decontamination materials are divided into two groups: (1) oxidizing, and (2) nonoxidizing.

Commonly used decontamination chemicals are: (1) one percent solution of table salt (2/3 cups of salt into 5 gallons of water) for 24 hours contact time,[1] (2) undiluted white vinegar for 20 minutes contact time,[1] (3) a diluted household bleach solution (> five percent sodium hypochlorite at a concentration of 3 ounces of bleach into 5 gallons of water) for a minimum of 1 hour,[2] (4) potassium permanganate solutions,[3] or (5) various quaternary ammonium and poly-quaternary ammonium compounds.[3]

- Be aware that some of these solutions may cause corrosion on metal surfaces and electrical connections.

[1] Refer to Protect Your Waters (2010).

[2] Refer to U.S. Fish and Wildlife Service (2007).

[3] Refer to Sprecher and Getsinger (2000).

- Any use of decontamination chemicals will involve disposal concerns and may pose user safety issues. PPE required.

- Before using any of the decontamination chemicals listed, be sure to refer to Protect Your Waters (2010), U.S. Fish and Wildlife Service (2007), and Sprecher and Getsinger (2000) for more detail.

Heat

Heating is generally regarded by most authorities as the most effective and easy to use of the control methods. Temperature and exposure time determine the effectiveness of temperature treatments. Live steam, autoclaving, or boiling are all believed to be 100-percent effective against all zebra and quagga mussel life stages. Water temperature used during hot water washing or rinsing must be maintained at >140 ºF at surface contact for 1-3 minutes‘ exposure time to bring the surface temperature up to 140 °F for 30 seconds.[4] Use a hand-held infrared temperature reader to verify 140 °F surface temperature. PPE required.

Hot Water, High-Pressure Washing

Using hot water, high-pressure washing is the most widely accepted method of cleaning invasive mussels from surfaces. The combination of lethal temperature water (at least 140 °F), combined with the mechanical action of high pressure is most effective. PPE use required. The following measures are recommended:

- Use a power washer unit that is capable of applying a flow rate of at least 4 gallons per minute with a nozzle pressure of 3,000 psi, and that is able to supply water at 140 °F or hotter at the surface point of contact.

- To begin the cleaning process, reduce the nozzle water pressure by adjusting the power washer or using reduced pressure attachments. Do not attempt to remove or detach mussels from the surface using high water pressure at this point in the cleaning process. The goal is to kill adult mussels with hot water while they remain attached to the surface.

- Rinse the entire surface to be treated with heated water for at least 30 seconds‘ exposure time at 140 °F to effectively kill all mussel life stages. To achieve this surface temperature, the operator may have to spray the surface for 1-3 minutes, depending on the size of the working area and the material composition of the surface.

[4] Certain early literature references cited water temperatures at 104 °F as being an effective temperature to kill zebra and quagga mussels; however, most current authorities support using the higher 140 °F water temperature for greater lethal effect on mussels. Using 140 °F minimum temperature throughout for heat treatment is recommended unless this manual specifies otherwise.

- After rinsing the surface at reduced water pressure, and having achieved a surface temperature of 140 °F for 30 seconds, maintain a hot water temperature and increase the nozzle pressure high enough to detach the mussels from the surface.

- Continue treatment on all exposed surfaces of the equipment..

Freezing

Adult zebra mussels have a relatively low tolerance to freezing. McMahon, Ussery, and Clarke (1993) reported 100-percent mortality when individual mussels were exposed to 14 °F for as little as 1.3 hours. However, clusters of mussels were more tolerant than individuals, and the corresponding freezing mortality exposure time at 14 ºF appears to be at least 4 hours.

Physical

Crushing is an effective way to kill individual adult mussels, but it is not effective against the attached veliger or juvenile life stage, nor is it practical for use over a large surface area. Any crushed adult remains should also be exposed to a hot water soak treatment prior to final disposal.

Desiccation

Desiccation is effective if sufficient time is allowed. In cool and highly humid settings, it is estimated that mussels can survive for over 40 days out of water. Drying times capable of killing mussels vary according to the month of the year, location, and relative humidity; therefore, no single drying time estimate can ensure a complete kill for all situations, unless a set maximum time is used. For specific information for a given month, location, and prevailing conditions, refer to the 100th Meridian *Quarantine Estimator for Zebra Mussel Contaminated Boats* drying schedule at the following Web site: http://www.100thmeridian.org/Emersion.asp (100th Meridian Initiative, 2011).

Use of Decontamination Methods for Small In-Water Equipment

The following methods should be employed when decontaminating small in-water equipment such as nets, waders, boots, buckets, etc.).

Field equipment used in bodies of water known or suspected to contain live zebra or quagga mussels at any life stage, all field equipment used to collect any samples, or equipment in contact with the body of water should be thoroughly cleaned before moving to another site outside the known range of these mussels. When possible, keep equipment at the same project area for use in that project area only to prevent cross contamination of other lands or water bodies. Whenever practical, the least infested (or least likely to be infested) sites should be visited first to reduce the risk of accidentally infesting a new area during field

work. If sampling is being performed to determine whether invasive mussels are present at a given site, assume that they are present and thoroughly clean all sampling equipment before moving to another site outside the known range.

- All field equipment must be inspected, and all visible mussels must be removed and killed. However, since the mussel immature life stages are microscopic and cannot be seen without laboratory equipment, do not rely on visual inspection alone; feel by hand for surface roughness.

- All field equipment can then be cleaned by soaking, dipping in, or scrubbing with hot water, or in one of the chemical decontamination solutions listed (see –Acceptable Decontamination Methods, Chemical Decontamination") if chemical decontamination is permitted by the manufacturer. If adult mussels are found during inspection, the equipment should be steam cleaned, washed with hot, high-pressure water, or dipped treated in hot water, and allowed to dry completely before the next use.

- Particular attention must be given to places where the mussels could be accidentally trapped, such as the treads of boots and waders, items of clothing or other cloth materials, and hinges of benthic grabs.

Use of Decontamination Methods for Large In-Water Equipment

The following methods should be employed when decontaminating large in-water equipment; for example, watercraft, construction and facility equipment, and water bags used during crane testing.

Compartments

- Bilge compartments, raw water holding tanks, such as a ballast tank, wet wells, live wells, and any other compartments that could hold water from an infested field site should be drained of water at the boat ramp before leaving the area. If it is not possible to drain all water held in holding tanks or compartments, a suction hose connected to a vacuum pump or a wet/dry shop vacuum can be used to remove remaining water. If a watercraft has carried water in these compartments from another location, remove all water into a container and heat it to at least 140 °F, or treat it with one of the decontamination solutions noted above. If adult mussels are found in these compartments, use the recommended hot water treatment (see –Acceptable Decontamination Methods, Heat)."

- After draining contained water, all water holding compartments should be filled with hot water for the appropriate contact time as noted above.

- If the compartment is too large to make filling practical, high pressure wash the compartment thoroughly with hot water as noted above.

Watercraft Hull Surfaces, Anchors, and Trailers

- Wash down with hot, high-pressure water. Then, visually inspect and feel by hand to remove any remaining foreign material.

- When using high-pressure, hot water washing, use a flushing attachment at reduced pressure to rinse all hard to reach areas and areas where high pressure may damage the equipment (such as the rubber booted gimbal of an inboard/outboard unit). Maintain a hot water contact time of 2-3 minutes with these areas to ensure that mussels are killed on the surface, since it may not be possible to remove them from hidden or sensitive areas

- Watercraft hulls, anchors, or trailers will be assumed to be free of live mussels if they have been thoroughly scrubbed, inspected, and any visible foreign materials have been removed or if they have remained dry and out of the water according to the 100th Meridian Quarantine Estimator for Zebra-Mussel Contaminated Boats drying schedule located at the following Web site: http://www.100thmeridian.org/Emersion.asp (100th Meridian Initiative, 2011).

Advisory on Cleaning Watercraft and Other In-Water Equipment:

There have been several anecdotal reports of boats that have been professionally cleaned, inspected, and certified as mussel free, then reinspected days later only to find additional live mussels. More than likely, these boats had been harboring adult mussels in hidden recesses of the boat. During cleaning, the hidden surfaces did not reach the required 140 °F temperature for 30 seconds, which is needed for mussel kill. Instead, the hot water irritated the mussels, causing them to migrate out of these hidden recesses and onto visible areas of the boat surface. This finding reinforces the following points:

- If equipment is used at a location known to be infested with an invasive species, the equipment should undergo a preinspection, followed by thorough cleaning, and a final inspection before being moved offsite.

- At the new location, the equipment should be inspected again, preferably by someone other than the original inspector before the equipment is placed into service.

- If, on reinspection, contamination is found on the equipment, do not allow the equipment entry on the new site; either return the equipment to the location of last use for additional cleaning or arrange for cleaning at a location that is specifically designed for equipment cleaning.

Best Management Practice:

Remember to use a flushing attachment at reduced pressure to rinse all hard to reach areas and those areas where high pressure may damage the equipment (such as the rubber booted gimbal of an inboard/outboard unit). Maintain a hot water contact time of 2 or 3 minutes with these areas to ensure that mussels are killed on the surface, since it may not be possible to remove them from hidden or sensitive areas.

When inspecting and cleaning, special attention should be given to the following: (1) cracks and crevices in which mussels may become trapped, and (2) aquatic plants harboring mussels that may be present on trailers or propellers. Particular attention must be paid to trailer pads made of carpet and foam rubber, which could trap tiny mussels. If possible, such material should be removed from trailers before doing work in invasive mussel-infested waters.

Watercraft Engine

If the watercraft engine is not a closed cooling system configuration (if the engine intakes its cooling water from the environment), the following applies:

- A hot water treatment is recommended for engine decontamination.
- Running a chemical solution, such as a bleach solution, through an engine to decontaminate it may violate the terms of the engine‘s warranty, or otherwise damage the engine, unless specified by the manufacturer.
- Chemical treatments are not well-suited for engine decontamination because the adult mussel is able to sense a toxic external environment and close up for extended periods of time.

Outboard. All outer surfaces of the motor must be cleaned to remove any clinging foreign material by washing with hot, high-pressure water. Then, visually inspect, feel by hand, and remove any remaining foreign material. Finally, decontaminate the engine cooling system by either: (1) placing the outboard motor into a barrel filled with 140 º F to 160 º F water and operating the engine for 5 to 10 minutes, or (2) using the appropriate flushing attachment, such as an ―earmuff" attachment. Operate the engine according to the ―Engine Decontamination Instructions" below.

Inboard/Outboard. All outer surfaces of the outboard unit must be cleaned to remove any clinging foreign material by washing with hot, high-pressure water (figure B-7). Then, visually inspect, feel by hand, and remove any remaining foreign material. Finally, decontaminate the engine cooling system by using the appropriate flushing attachment, such as an "earmuff" attachment. Operate the engine according to the "Engine Decontamination Instructions" below.

Inboard Engine. All surfaces of the propeller, driveshaft, driveshaft bearing supports, rudder, and driveshaft bearings must be cleaned to remove any clinging foreign material by washing with hot, high-pressure water. Then, visually inspect, feel by hand, and remove any remaining foreign material. Finally, decontaminate the engine cooling system by using the appropriate flushing attachment. Operate the engine according to the "Engine Decontamination Instructions" below.

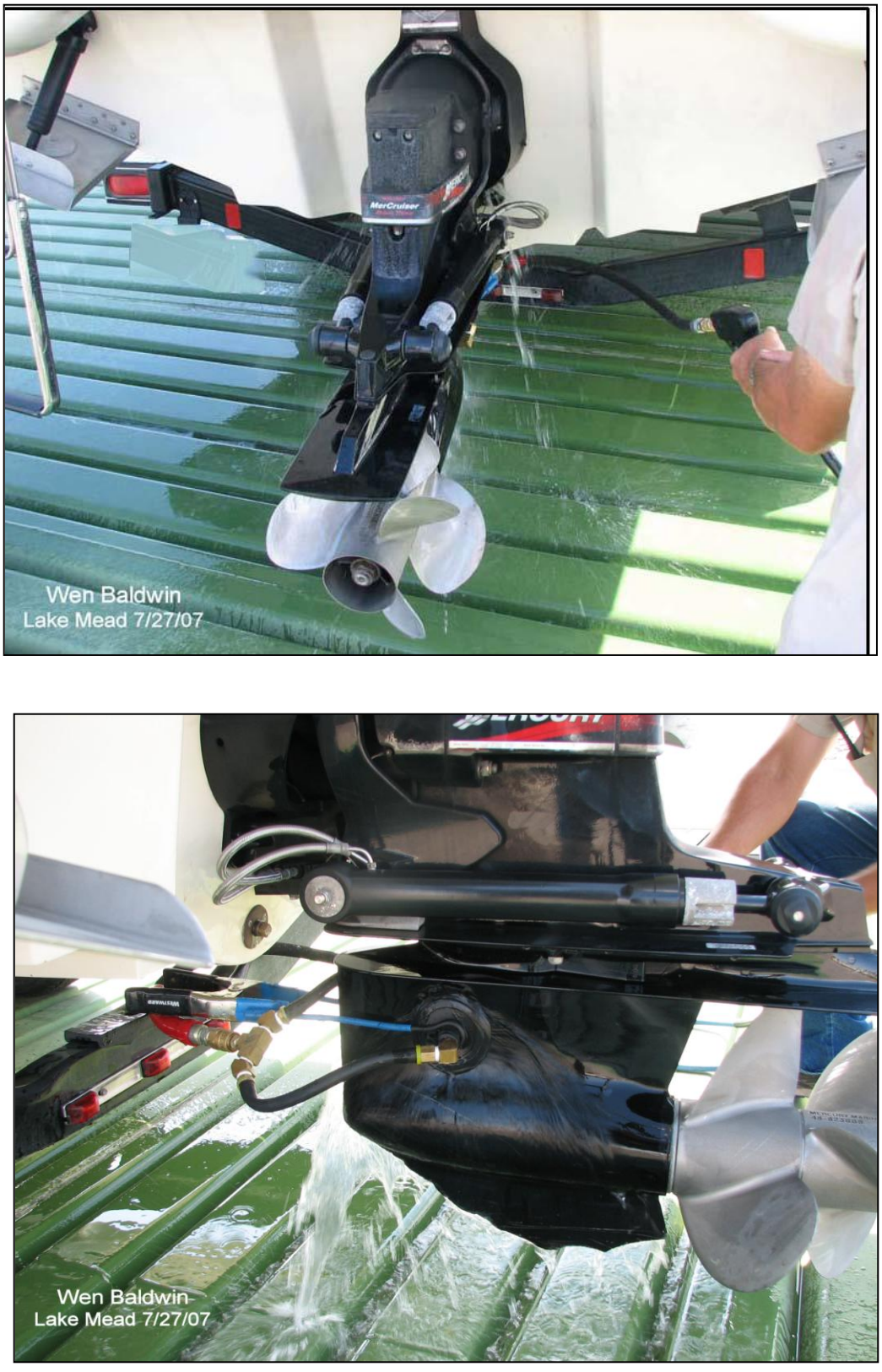

Figure B-7. Inboard/outboard engine flushing (photo courtesy of Wen Baldwin, 2007).

Read the following instructions completely before using this procedure.

- Use the appropriate attachment, such as an ~~–e~~ar muff" attachment, to flush the watercraft engine cooling system. Refer to the manufacturer's directions for flushing attachment hookup to the engine. PPE required.

- Stay clear of the propeller and keep other persons away too during the flushing process.

- Set the watercraft transmission in neutral gear.

- Connect the flushing attachment to the power wash unit or other hot water source.

- Start hot water flowing through the engine and wait for water to exit from the cooling system outlet ports as a steady stream of water. If water does not flow as a strong, continuous stream from the outlet ports, there may be some debris or mussels already inside the cooling system that are blocking the free outflow of water. Examine the water intake ports closely, and check the intake filter screens for any evidence of mussels or other blockage. After this concern is resolved, resume the flushing procedure.

- Check the outflow water temperature with a handheld thermometer, or a handheld infrared temperature reader. If the engine is cold, the outflow water temperature maybe much cooler than the required 140 degree F. required to kill mussels. If this occurs, heat is probably being transferred from the flushing water to the cold engine mass. Wait for the outflow water to reach 140 degrees F. before proceeding.

- Some watercraft motor manufacturers allow engines to be operated during the flush procedure, while some do not. In addition, some manufacturers limit the input pressure of the flushing system. For example, certain models of Mercury™ engines specify a flushing system pressure limit of 45 psi. Refer to the manufacturer's directions prior to attempting engine flushing.

If the manufacturer allows flushing with engine running: Start the engine and run at the lowest idle speed for 2 minutes. Make sure the required 140 °F temperature is maintained in the outflow water. Also make sure the engine does not reach an overheated condition. On certain engines, it is possible that a low coolant volume in the cooling system will not properly register an overheat condition on the engine temperature gauge; therefore, it is very important to monitor the temperature of the outflow water. When completed, shut down the engine first, and then shut off the water supply. Disconnect all flushing attachments.

Warning:
Most hot water power washers have a flow rate of 4 gallons per minute or less. Be sure to check the flow rating of your washer! Using less than 5 gallons per minute flow rate when flushing the engine cooling system may cause engine damage if the 2-minute engine run time requirement is exceeded! Operate the engine at only low idle speed during flushing.

If the manufacturer does not allow flushing with engine running: Proceed according to the manufacturer's directions with engine shut down. Make sure the required 140 °F temperature is maintained in the flushing outflow water. When completed, shut off the water supply and disconnect all flushing attachments. Hot water flushing on an engine that is not running can usually exceed the 2-minute limit imposed for an engine that is running.

Construction and Facility Equipment

As discussed previously, special attention must be given to inspecting and cleaning construction and facility equipment. Decontaminate construction and facility equipment using much the same approach for watercraft cleaning where a hot water, high-pressure cleaning method is indicated. For cleaning encrusted mussels from the interior of pipes, water jetting systems using high pressure attachments, such as a water jetting spin nozzle can be used (figure B-8). Depending on the equipment item, desiccation or freezing may be the preferred decontamination method. Abrasive sand blasting may also be an appropriate cleaning measure, depending on the particular equipment item, or the coating properties of the item. If desiccation is used, proceed according to the drying time calculated by the 100th Meridian Quarantine Estimator for Zebra-Mussel Contaminated Boats drying schedule located at the following Web site: http://www.100thmeridian.org/Emersion.asp (100th Meridian Initiative, 2011).

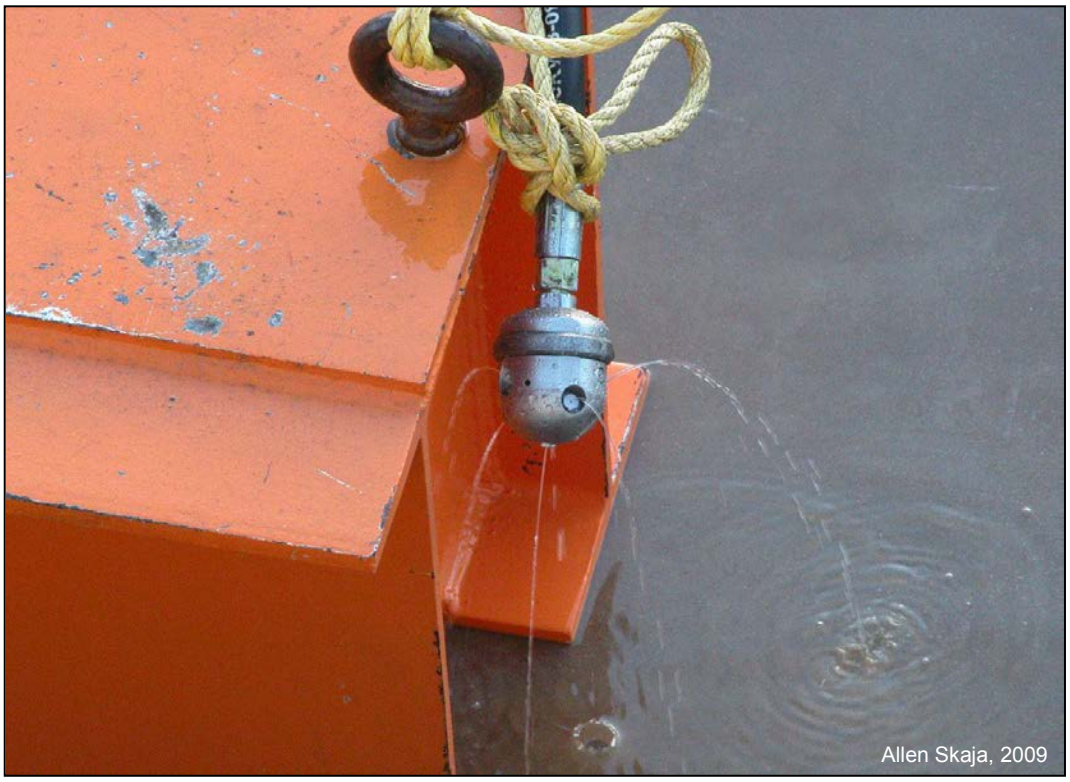

Figure B-8. Water jetting spin nozzle for cleaning out small diameter pipe infested with quagga mussels (photo courtesy of Allen Skaja, 2009).

Facility Equipment Materials for Mussel Control

Metals. Copper and many copper alloys prevent the attachment of mussels due to the toxicity of available copper ions to the mussels (figures B-9 through B-11). In general, as the copper content of an alloy increases, corrosion resistance decreases; and, as the copper content decreases, the effectiveness to repel mussels also decreases due to the lack of copper ions at the metal‘s surface, as shown by the 90-10 copper-nickel alloy in figure B-12. The gradation of copper ion availability in metals, and their ability to resist mussel infestation, is dramatically illustrated in figures B-9 through B-12. The test panel in figure B-9 has the greatest available copper ions; while figure B-12 has the least. In particular, note that in figures B-9 and B-10, even the ropes attached to the test panels are free of mussels, due to copper ions in solution in the surrounding water. In addition to the corrosion concerns, copper or copper alloy in-water facility components have the tendency to contribute available copper to fresh-water systems that may cause concerns for elevated copper levels. Zinc has also been shown to prevent the attachment of mussels in soft water (U.S. Army Corps of Engineers, 1994), but has been proven ineffective in hard water on the Colorado River (Bureau of Reclamation, 2009). Hard water has a high carbonate concentration which reacts with the zinc ions to form a precipitate zinc carbonate. Thus, the carbonate consumes the zinc ions before they can repel mussel attachment.

Figure B-9. This copper plate has been submerged for 18 months in Lake Havasu, notice there are no mussels on the rope or on the plate (photo courtesy of Allen Skaja, 2009).

Figure B-10. This brass plate has been submerged for 18 months in Lake Havasu; notice there are no mussels on the rope or on the plate (photo courtesy of Allen Skaja, 2009).

Figure B-11. This bronze plate has been submerged for 18 months in Lake Havasu; notice the rope has mussels attached while the plate is mussel free (photo courtesy of Allen Skaja, 2009).

Figure B-12. This 90-10 copper nickel fish screen has been exposed for 4 months; notice the amount of mussels attached to the surface (photo courtesy of Allen Skaja, 2009).

Coatings. There are two types of coatings that potentially resist mussel attachment, antifouling and foul release coatings (Hellio and Yebra, 2009). Antifouling coatings rely on the release of a biocide to keep the mussels from attaching (figure B-13). The most common antifouling paint contains copper, but there are some products available that have organic biocides. The service life of these coating systems depends upon flow rates, water chemistry, pH, temperature, and coating thickness. Foul release coatings rely on surface chemistry to form a slick surface to prevent the mussels to attach firmly to the coating (figure B-14). Foul release coatings are nontoxic. In static or low water flowing conditions the mussels will attach, however can easily be cleaned with a garden hose or low pressure waterjetting. In general, the foul release coatings are not as durable as the antifouling coatings and could be damaged by abrasion, gouging, or mechanical cleaning.

Figure B-13. Antifouling coating test panel has been in the Lower Colorado River at Parker Dam for 4 months; notice the attached adult quagga mussels on the test panel and anchoring ropes (photo courtesy of Joe DiVittorio, 2008).

Figure B-14. This is an example of a foul release coating that has been in the water for 18 months. Mussels and algae growth may attach to the surface under certain flow rates; however, they are easily removed (photo courtesy of Allen Skaja, 2009).

Water Bags Used During Crane Testing

As discussed previously, special attention must be given to inspecting and cleaning water bags used during crane testing. Crane testing companies often use water bags by filling the bag with water to the corresponding weight for the testing process. These bags can be used at various locations across the country. At the end of crane testing, the bag is drained and can be moved to a new location. Water bags used for crane testing generally cannot be easily inspected at the level required to find the mussel veliger life stage. If the water bag was filled with raw water during its prior use and was not decontaminated, assume it is contaminated. During the crane testing procedure, the water bag will be filled with water for only several hours, and then it will be drained. Therefore, the main risk factor is veliger mussel contamination in the bag‘s residue water.

If the crane testing company can provide certification that the water bag was filled only with potable water at its last use location or was otherwise properly decontaminated, the bag can be assumed to be free of contamination.

Decontamination of a water bag may include the general treatment methods described below for all other equipment, provided the treatment complies with the water bag manufacturer‘s specifications. Treatments such as chemical decontamination, heat, freezing, physical, and desiccation may be considered for use based upon the bag‘s materials, construction, design, and specifications. All water bag decontamination treatments are the responsibility of the crane testing company.

Chemical Decontamination. If allowed by the manufacturer‘s specifications, the bag may be decontaminated for veliger mussels using the chemicals listed for the appropriate contact time. However, any chemical treatment would produce large quantities of wastewater and require special handling and disposal.

Heat. Heating a water bag directly is not a recommended treatment option unless specifically allowed by the water bag manufacturer. Hot water pressure washing may be an acceptable option as allowed by the manufacturer‘s specifications.

Freezing. Freezing a fully drained water bag is a promising treatment option when allowed by the manufacturer‘s specifications. Adult zebra mussels have a relatively low tolerance to freezing. Mussel veligers are thought to be more susceptible to freezing; however, more research is needed. A100-percent mortality when individual adult mussels were exposed to 14 ºF for as little as 1.3 hours has been reported in recent scientific literature (McMahon, Ussery, and Clarke, 1993). Clusters of adult mussels were more tolerant than individuals, and the corresponding freezing mortality exposure time at 14 ºF appears to be at least 4 hours.

Physical. Water microfiltration, capable of removing immature mussel life stages is a physical treatment measure. If using a raw water source, a portable microfiltration unit, with associated connectors could be used for bag filling. Of course, all connections in contact with raw water would require decontamination prior to use in the next water body to prevent potential mussel transfer.

Desiccation. Desiccation as a treatment option might include air drying the bag, assisted by fan circulation using room temperature or moderately heated air. Using dehumidified air will assist the desiccation process and shorten time requirements. If air drying is used, the length of treatment must be according to the *100th Meridian Quarantine Estimator for Zebra-Mussel Contaminated Boats* drying schedule for successful treatment. See the following Web site: http://www.100thmeridian.org/Emersion.asp (100th Meridian Initiative, 2011).

Inspection and Decontamination Standards for Dive Gear and Related Equipment

In compliance with State and Federal laws, under no circumstances shall zebra or quagga mussels (including veligers) be transported away from an infested site. Therefore, all gear exposed to diving water must be treated onsite after the completion of the dive activities. Dive gear is often used in zebra or quagga mussel infested waters; therefore, it is vital that the equipment be properly treated using inspection and decontamination standards. Because dive gear is not exposed to zebra or quagga mussel infested waters over a long term, adult mussel infestation of dive gear is less of a concern. However, there is higher probability that mussel veligers could become trapped in or attached to dive gear during normal duration dives. Veligers would be invisible to the unaided human eye during visual inspection. Any adult mussels found on dive gear would be easily spotted and must be removed during visual inspection. Exposed dive gear requiring inspection and decontamination includes equipment associated with scuba, remotely operated vehicle (ROV), and surface supplied air (SSA) activities. This protocol applies to all dive gear used in all water bodies, not just waters thought to be infested.

- Do not assume any diving water is uninfested.
- When making dives at multiple sites, the known (or most likely) infested site should be the last dive of a multiple dive operation.
- Drain water from all equipment before leaving the dive site.
- Remove all mud and vegetation from your equipment.

- Visually inspect all gear for adult mussels attached to or trapped in equipment.

- Feel surfaces by hand for rough spots that may indicate attached juvenile mussels.

Four suggested dive gear decontamination methods are listed below for veliger decontamination.

Dive Gear Decontamination Methods

Saltwater Treatment

Use saltwater (sodium chloride) as described below. Of these methods, perhaps the most challenging for dive team members to use involves a saltwater decontamination solution. While a saltwater solution is widely accepted in the literature as being very effective in killing zebra and quagga mussel veligers, and the solution is easy to prepare and use, disposal of the spent saltwater solution may be complicated by variable disposal requirements from State to State and among local governments.

What might be an acceptable disposal technique for the spent saltwater solution in one locale may not be acceptable in another. Therefore, it is not possible for the manual to discuss every saltwater disposal requirement that divers might encounter. If the saltwater decontamination method is selected, the dive team coordinator is advised to contact the environmental staff at the responsible field or area office. Advance contact with the environmental staff is highly recommended since discussion with other agencies may become necessary. It is preferable, when possible and if allowed by the local treatment plant authority, that the saltwater decontamination solution be disposed of into a domestic sewer drain. In remote locations with no reasonable access to domestic sewer drains, dispose of the spent saltwater solution on the ground near to the infested water body, or to another ground location recommended by the environmental staff or local facility manager.

Dedicated Equipment

The dive team would purchase and use a separate set of dive equipment dedicated for work in known infested water bodies only. Instead of purchasing extra dive equipment for all divers on the team, the dive team would select a limited number of divers with experience in performing zebra and quagga mussel inspection.

Quarantine

All exposed dive equipment must be contained (kept separated from other dive gear in bags, etc.) and then thoroughly dried in storage before using again. This would prohibit diving with possibly contaminated dive equipment for a minimum quarantine period of time based on storage humidity. This is more easily accomplished when a separate dedicated set of dive gear is purchased for the diving in infested waters only.

Cold Temperature

Freezing is a possible option in some places because many Reclamation facility locations are at high altitude and dive operations are conducted year round. When outdoor air temperature is below freezing, drain excess water from dive equipment and leave it outside overnight, or use a refrigerated freezer system, allowing equipment to freeze. Freezing is appropriate for dive equipment that does not contain water and does not break, such as dive suits, fins and gloves, etc. Ensure that freeze time is adequate for a complete freeze. Use caution with dive gear that could hold water, such as valves or hoses, because expanding water may damage equipment. Make sure all components are completely free of water before freezing, or use a different treatment method.

Notes on Saltwater Decontamination Treatment: Except for ROV, SSA, and other equipment as noted, the decontamination protocol below uses a desirable decontamination water temperature of 104 °F for greater efficacy. However, heated water may not be available at remote locations when decontamination of dive gear is necessary. Therefore, decontamination of dive gear in the field using a cold saltwater solution is the recommended minimum treatment option. Zebra and quagga mussel veligers are far more susceptible to salinity than adult mussels. Kilgour and Keppel (1993) recorded acute toxicity for zebra mussel veligers at 4.5 parts per thousand (ppt) (or 0.45 percent) salinity. Mixing the saltwater decontamination solution at the rate of ½ cup of table salt per gallon of water approximates the salinity of seawater at 35 ppt (or 3.5 percent) salinity. The salinity of this solution is almost eight times more concentrated than the acute toxicity of 4.5 ppt noted.

Do not use a chlorine decontamination solution. Chlorine is not safe for dive gear decontamination due to a risk of residual chlorine gas inhalation through the regulator. It is also possible that chlorine could damage glue and other materials associated with diving gear from repeated chlorine washing. Equipment failure during diving may be hazardous to the diver. The use of normal chlorinated tap water (e.g., drinking water) to prepare the saline decontamination solution does not pose a chlorine risk to the diver.

Notes on Desiccation and Drying Time: Drying dive gear between dives is important, but the Reclamation dive team is often tasked to dive multiple locations over several days, making equipment drying difficult. Follow an accepted decontamination method and, whenever possible, allow dive gear to dry completely between dives. When used alone, drying is capable of killing mussels, but drying time effectiveness varies widely according to the mussel life stage, month of the year, location, and relative humidity; therefore, no single drying time estimate can ensure a complete kill for all situations, unless a set maximum time is used. Zebra and quagga mussel veligers are far more sensitive to desiccation than are adults. Although developed for adult mussels, as a guide, refer to the 100th Meridian *Quarantine Estimator* drying schedule at the following Web site: http://www.100thmeridian.org/Emersion.asp (100th Meridian Initiative, 2011).

Inspection and Saltwater Decontamination Protocol for Dive Gear

Flashlights, weight belt, mask, snorkel, fins, notepad, hood, gloves, regulator, buoyancy control device (BCD), etc.

1. Visually inspect inside of pockets. Scrub all surfaces with a brush as required to remove foreign material.

2. Carefully inspect the inside of BCD.

3. Soak all dive gear in saltwater. If available onsite, use hot water (104 °F) to prepare the decontamination saline solution. Note that water temperatures greater than 104 °F may shorten the life of dive gear due to glue or plastic failure. A failure in the equipment, at the seams of a wet suit for example, may be hazardous to the diver. Use a salt concentration of ½ cup commercial table salt per gallon of water.

4. Soak gear ½ hour, rinse with noninfested fresh water. Allow gear to dry completely prior to next use.

For Dry Suit:

1. Visually inspect inside of pockets and bottom of boots.

2. Close off valve, wrist, and neck openings of dry suit. Prepare and use the saltwater solution as described above. Immerse in saltwater for ½ hour.

3. Rinse with noninfested fresh water. Carefully inspect valves and zippers to prevent salt corrosion.

4. Allow to dry completely prior to next use.

For ROV, SSA, Umbilical Cord, and Scuba Tanks

1. Use a salt concentration of ½ cup of commercial table salt per gallon of cold water. Soak gear ½ hour, rinse with noninfested fresh water.

2. Allow equipment to dry completely prior to next use.

Product Vendors

A list of vendors that provide products and services for cleaning equipment and vehicles follows. No endorsement of listed vendors or products is implied.

Spill containment berms and water tanks:

Berg Containment Systems
16124 E. Euclid Avenue
Spokane WA 99216
1-800-228-8277
http://bergco.com

Interstate Products, Inc.
3921 Sawyer Road
Sarasota FL 34233
1-800-474-7294
1-800-448-6329 (fax)
http://www.interstateproducts.com

Polystar, Inc.
2030 Midway Drive
Twinsburg OH 44087
330-963-5100
1-800-275-3453 (toll-free)
330-405-6186 (fax)
http://www.polystarcontainment.com

Wash water recycling systems:

InterClean Equipment, Inc.
3939 Bestech Drive, Suite B
Ypsilanti MI 48197
734-975-2967
http://www.interclean.com/Default.htm

Watercraft decontamination vendors:

H_2O Power Equipment
6057 E. 49th Avenue
Commerce City CO 80022
1-800-255-6354
http://h2opowerinc.reachlocal.net/

Hydro Engineering, Inc.
865 W. 2600 S.
Salt Lake City UT 84119
1-800-247-8424
http://www.hydroblaster.com

Hydro Tek Systems, Inc.
2353 Almond Avenue
Redlands CA 92374
909-799-9222
1-800-274-9376
http://www.hydrotek.us

Industrial Equipment
830 Cherry Street
Chico CA 95928
1-800-287-8306
http://www.industrial-equipment.biz/

Little Red Hen, LLC
13360 Rose Creek Road
Bozeman MT 59715
406-585-5858
http://www.rrmobileservices.com/janda/inner.php?PageID=23

Prefix
1300 West Hamlin Road
Rochester Hills MI 48309
248-650-1330
http://www.prefix.com

S-K Environmental
PO Box 4
Okanogan WA 98840
509-322-6909
http://s-k-enviro.com/

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Appendix C
Species of Concern

Contents

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Appendix C
Species of Concern

The following list of exotic and undesirable native plants and animals represents a partial listing of common species that have caused serious problems in the western United States. Although these examples do not constitute a complete list of problematic plants and animals, the inspection and cleaning protocols that prevent the spread of these species is equally applicable to other species you may encounter in the field.

Submersed and Floating Aquatic Plants

Hydrilla (*Hydrilla verticillata*) (L.f) Royle)
Curlyleaf pondweed (*Potamogeton crispus* L.)
Sago pondweed (*Stuckenia pectinatus* (L.) Boerner)
Eurasian watermilfoil (*Myriophyllum spicatum* L.)
Giant salvinia (*Salvinia molesta* Mitchell)
Waterhyacinth (*Eichornia crassipes* (Mart.) Solms)

Emergent Aquatic, Wetland, and Riparian Plants

Alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb)
Floating primrose willow (*Ludwigia peploides*)
Parrotfeather (*Myriophyllum aquaticum aquaticum* (Vell.) Verd)
Flowering rush (*Butomus umbellatus* L.)
Purple loosestrife (*Lythrum salicaria* L.)
Giant reed (*Arundo donax* L.)
Common reed (*Phragmites austalis* spp.)
Saltcedar (*Tamarix* spp.)

Terrestrial Plants

Brazilian pepper (*Schinus terebinthifolius* Raddi)
Russian olive, autumn olive, cherry silverberry *(Eleagnus* spp.)
Russian knapweed (*Acroptilon repens* spp.)
Spotted knapweed (*Centaurea biebersteinii* spp.)
Diffuse knapweed (*Centaurea diffusa* spp.)
Leafy spurge (*Euphorbia esula* L.)
Yellow starthistle (*Centaurea solstitalis* L.)
Perennial pepperweed (*Lepidium latifolium* L.)
Canada thistle *(Cirsium arvense* spp.)

Bull thistle (*Cirsium vulgare* spp.)
Plumeless thistle (*Carduus acanthoides* spp.)
Musk thistle *(Carduus nutans* spp.)
Whitetop (*Cardaria* spp.)
Cheatgrass (*Bromus tectorum*)

Mollusks

Asian clam (Corbicula fluminea Muller)
New Zealand mudsnail (Potamopyrgus antipodarum Gray)
Zebra mussel (Dreissena polymorpha Pall.)
Quagga mussel (Dreissena rostriformis bugensis Andrusov)

Notes: Cleaning watercraft, trailers, motors could also limit the introduction of other invasive species, such as the Spiny water flea (*Bythotrephes cederstroem*), an organism of great concern in the Great Lakes.

Plant information is excerpted from the U.S. Army Corps of Engineers, Engineer Research and Development Center, –Aquatic Plant Information System," version 2.99, and –Noxious and Nuisance Plant Management Information System," version 5.3, fall 2003. Some plant pictures come from other sources, and are cited as such. Information on other species comes from various sources.

Hydrilla

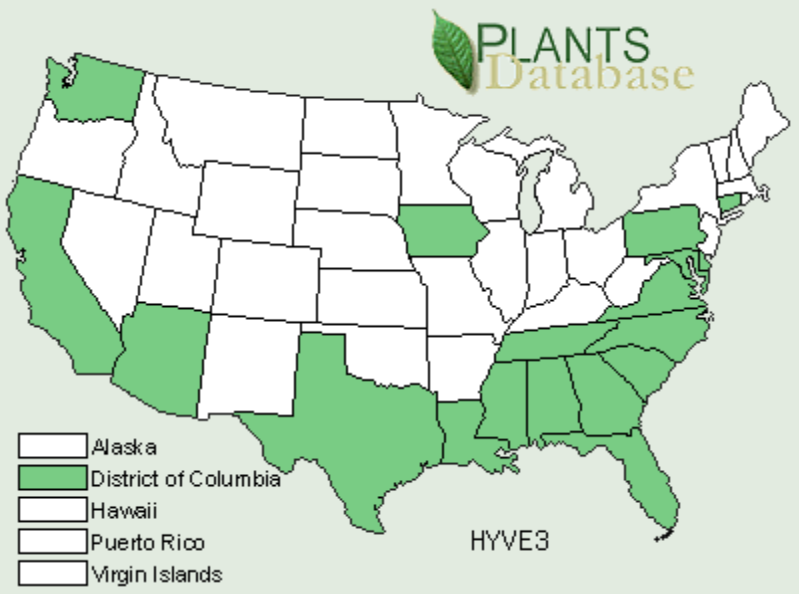
Family

Hydrocharitaceae

Home Range/U.S. Introduction

Hydrilla verticillata (L.f.) Royle is an introduction from the Old World (Cook & Luond 1982) that was first discovered in the United States in 1960 and is now abundantly naturalized in many parts of the United States (Langeland 1996). Plants have attractive foliage and are planted in aquaria which are often emptied into freshwater habitats. Hydrilla is easily confused with *Egeria densa* Planch., Brazilian elodea or Egeria, and *Elodea canadensis* Michx., Canadian elodea, Waterweed.

U.S. Range Map



Species Description

The plants grow submersed, are mostly perennial but sometimes annual, and have horizontal stems in the substrate forming tubers under certain conditions. Stems are ascending and usually are sparsely branched until the plants near the water surface and then become profusely branched. Under certain conditions, turions (actually bulbil-like structures) form in the leaf axils. Stems can be up to 8.5 m long and grow to the surface of the water where the branchlets extend horizontally. Leaves are 1-nerved, sessile, whorled, 3 to 12 at a node but mostly 5 or more, mostly shorter than 1.5 cm long, linear to lanceolate or rarely widely ovate, broadest at the base, the sides nearly paralleling to near the acute tip that terminates in a single spine cell. Leaf margins are serrate, the teeth visible to the naked eye. Fresh leaves are notably rough to the touch. The midrib on the upper surface is often tinged with red and on the lower surface, usually, has 1-celled sharp teeth or spines. Flowers are unisexual, arising from the leaf axil; plants are monoecious or dioecious. The flowers are small, less than 6 mm in diameter, translucent to white; female flowers are usually produced in the fall and are on long thread-like stalks 2 to 4 cm long from leaf axils of the upper branches that carry the flowers to the water surface. Male flowers are solitary, small, on short stalks in the leaf axil and break off as buds, opening explosively on the water surface.

Hydrilla can usually be differentiated from Canadian elodea (*Elodea canadensis* Michx.) and egeria (*Egeria densa* Planch.) by the following characters:

Leaves mostly in whorls of 4 at sterile nodes, leaves 1.4 to 2.5 cm long. *Egeria densa*

Leaves of stems at growing tips at water‘s surface usually in whorls of 3 or 5 or more; leaves not or mostly not exceeding 1.5 cm long, the longest sometimes to 2 cm

Leaves mostly in whorls of 5 or more; margins of the leaves with teeth perceptible to the naked eye; midribs on lower leaf surface (when fresh) with a few conical protuberances tipped by sharp 1-celled teeth; fresh leaves notably rough to the touch. *Hydrilla verticillata*

Leaves mostly in whorls of 3; margins of the leaves not having teeth perceptible to the naked eye; midribs of lower leaf surface not pronounced, not bearing teeth; fresh leaves not rough to the touch. *Elodea canadensis*

Habitat/Growth Characteristics

Plants grow in canals, springs, streams, ponds, lakes and reservoirs. Most populations of hydrilla in the United States are dioecious. However, populations of monoecious hydrilla occur in North Carolina and northward into the Mid-Atlantic States (Langeland 1996). Hydrilla can reproduce by four methods: fragmentation, tubers, turions, and seed. Tubers in the hydrosoil can remain viable for several years (Langeland 1996) and allow the plant to survive cold temperatures and periods of drought (Tarver *et al.* 1986). Although the importance of seed production in the spread of hydrilla has not been researched extensively, it is probably of minor importance compared to vegetative reproduction (Langeland 1996). Hydrilla has a high growth rate and lower light requirement for photosynthesis than most other submersed plants (Langeland 1996) which allows it to grow at greater depths and outcompete most other species. It also forms a dense canopy at the surface of the water and ―shades out” other submersed plants (Tarver *et al*. 1986).

Problems

This species is probably the worst submersed aquatic weed in the United States. Plants form large, dense populations which displace native species, restrict flow, and impair small boat navigation and other recreational uses (Tarver *et al*. 1986, Langeland 1996). In addition to being spread by natural fragmentation, plants are sometimes spread from lake to lake by fragments attached to boat motors and trailers. Hydrilla also is thought to be intentionally introduced into ―new” water bodies in an effort to enhance sport fishing for black bass.

References

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Curlyleaf Pondweed

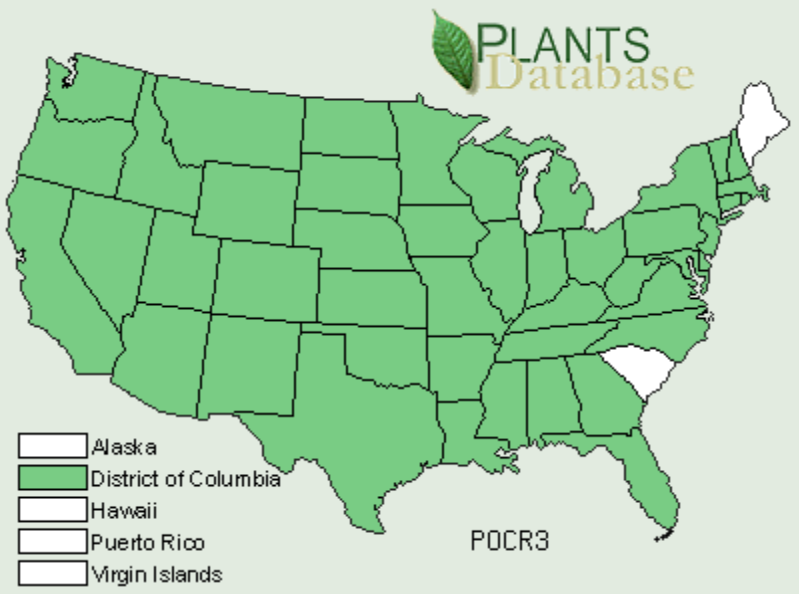
Family

Potamogetonaceae

Home Range/U.S. Introduction

Curly pondweed, *Potamogeton crispus* L., is native to Eurasia and apparently was introduced into the United States in the mid 1800‘s (Stuckey 1979). Prior to 1900, the distribution of *P. crispus* was the northeastern United States. By 1930 curly pondweed had spread westward to several states of the Great Lakes region. The species has since spread across much of the United States (see distribution map), presumably by migrating waterfowl, intentional planting for waterfowl and wildlife habitat, and possibly even as a contaminant in water used to transport fishes and fish eggs to hatcheries (Stuckey 1979).

U.S. Range Map



Species Description

Curly pondweed is a perennial and has elongate, slender rhizomes that are buff or reddish. The stems of curly pondweed are flattened. Leaves are entirely submersed, sessile, oblong to broadly linear, 3 to 8 cm long and 5 to 12 mm wide. The leaf tip is usually rounded and sometimes minutely cuspidate. The leaf margins are finely toothed, undulate and crisped. Stipules are translucent and soon disintegrating. Bur-like turions that are up to about 5 cm long often form during the spring and late summer months and consist of three to seven small, thickened leaves that project from the stem at a slight upward angle. Flowers are borne on a short spike that extends above the surface of the water. The fruits are flat, 4 to 6 mm long (including the beak) and have a distinct, pointed beak that is erect or somewhat curved and about 2 to 3 mm long.

Habitat/Growth Characteristics

Potamogeton crispus grows in lakes, reservoirs, ponds, rivers, streams, and springs. It can grow in clear to turbid and polluted waters and in alkaline or brackish waters (Stuckey 1979). Curly pondweed produces seed, but the importance of seed in the spread and maintenance of populations is unknown (Stuckey 1979) and is assumed to be less important than turions (Sastroutomo 1981). In most portions of its range, *Potamogeton crispus* typically reaches peak biomass in the late spring or early summer months, forms turions, then declines and –survives" the warmer months in a dormant state (i.e., as a turion) (Cypert 1967, Stuckey 1979, Sastroutomo 1981, Tobiessen and Snow 1984, Nichols and Shaw 1986). As water temperatures cool during the late summer or fall months,

the turions germinate, grow through the winter months with the plants reaching peak biomass in the spring before most other submersed macrophytes begin their growth cycle. Once established, the plants regrow and form colonies from rhizomes.

Problems

Dense colonies of curly pondweed can restrict access to docks and sport fishing areas during spring and early summer months. Because populations of curly pondweed usually decline during the summer months, it does not directly compete with many of the native submersed species.

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Sago Pondweed

(Photo: John Madsen)

Synonym(s)

Stuckenia (formerly *Potamogeton) pectinatus* L.

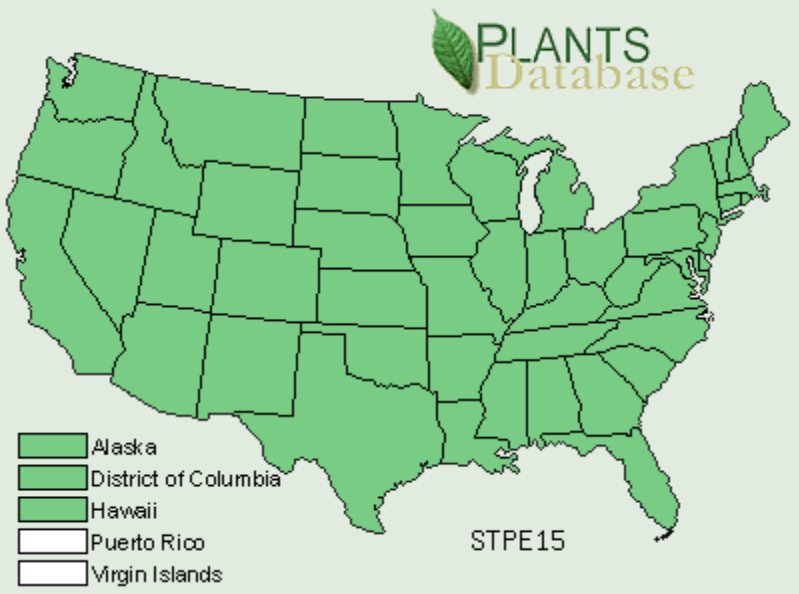
Family

Potamogetonaceae

Home Range/U.S. Introduction

Sago pondweed, *Stuckenia pectinatus*, is native and occurs throughout most of the United States. Sago pondweed lacks floating leaves and can be distinguished from other species of pondweed having only narrow underwater leaves by stipules that are adnate to the leaf blade for 90 percent of their length and by fruits that have an evident beak (Haynes 1978).

U.S. Range Map



Species Description

Sago pondweed is a perennial and has thin, creeping rhizomes that are matted and often end in tuberous bulblets. The stem is slender, about 1 mm in diameter, simple at the base but much branched toward the summit. All the leaves are submersed, linear to filiform, 3 to 10 cm long, about 1 mm wide. Each leaf has one to three nerves and an acute to attenuate apex. The stipules are 2 to 5 cm long and are adnate to the leaf for approximately 90 percent of stipule length. Flowering stalks (peduncles) arise from the leaf axils and are from 3 to 10 cm long. The flowers are sessile, in whorls of 2 to 5 and on spikes 1 to 4 cm long. Fruits are plump, 2.5 to 4 mm long with a rounded dorsal keel and a short beak.

Habitat/Growth Characteristics

Stuckenia pectinatus grows in fresh, alkaline, brackish, or saline waters of lakes, ponds, rivers, streams, irrigation canals and coastal marshes. Sago pondweed reproduces by seed and vegetatively by rhizome growth and from bublets (tubers). Environmental conditions influencing the formation and germination of tubers have been studied by several investigators (Spencer 1987, Madsen and Adams 1988, Spencer and Ksander 1992). Spencer and Ksander (1992) found that tubers collected from canals in California germinated in response to water-saturated substrate at temperatures of 15, 20, and 25 degrees C. These data suggest that flooding of canals could induce the germination of sago pondweed tubers during periods when ambient temperatures were within this range. After the removal of water, the ~~t~~errestrial" form of the plant would likely be produced and could be more easily controlled with other techniques (e.g., herbicides).

Problems

Sago pondweed sometimes grows in dense colonies that can impede boating and interfere with other types of recreational activities (Tarver *et al*. 1986, Hoyer *et al.* 1996). Waterfowl consume the seeds, rhizomes, and bublets (tubers) of sago pondweed. Because sago pondweed is considered to be a valuable food plant for waterfowl, it has been widely planted beyond its original range (Muenscher 1944).

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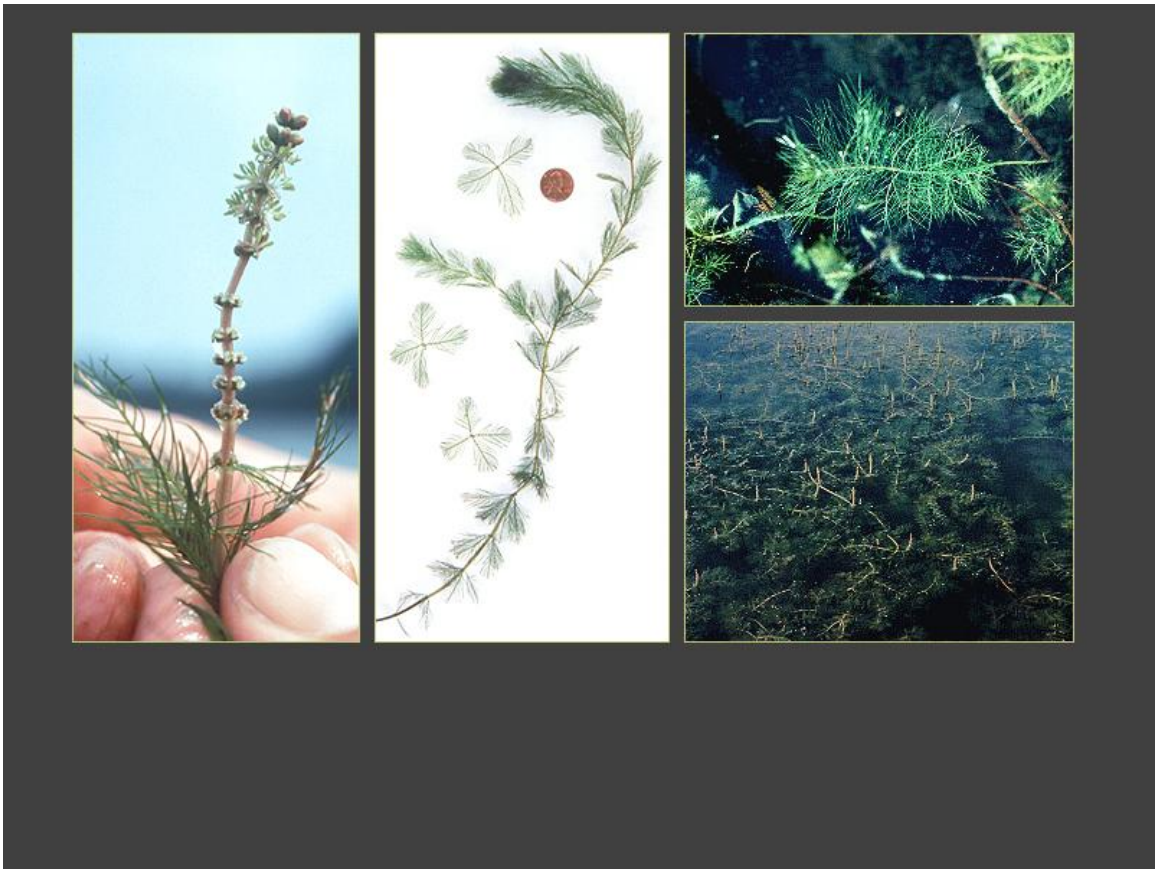
Eurasian Watermilfoil



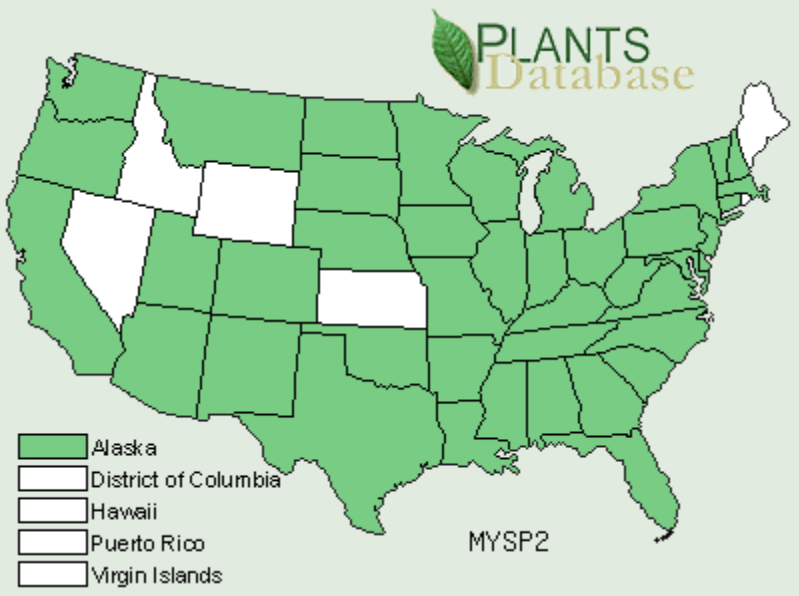
Family

Haloragaceae

Home Range/U.S. Introduction

Myriophyllum spicatum L. is an aggressive weed that is native to Europe, Asia, and North Africa. Because of morphological similarities and past taxonomic confusion between Eurasian watermilfoil and the native, northern watermilfoil (*Myriophyllum sibiricum* Komarov), it is difficult to determine the exact time of introduction. A study of herbarium specimens by Couch and Nelson (1985) indicate Eurasian watermilfoil was established in the United States by the 1940‘s, while other investigators report that Eurasian watermilfoil may have been in the United States since about 1900 or even earlier (Reed 1977).

U.S. Range Map



Species Description

Plants of Eurasian watermilfoil are rooted and submersed except for a short (3 to 8 cm) emersed flowering spike. Primary stems are generally branched and often form a dense canopy on the water‘s surface. Leaves are whorled, 4 or rarely 5 leaves per node, each leaf pinnately dissected into narrow, linear segments. The number of pairs of leaf segments is highly variable, ranging from 5 to 24 for each leaf. Leaves cling to the stem above each node when removed from the water. Turions are absent. The flowers are whorled and in spikes with the pistillate flowers at the lower nodes of the spike and staminate flowers at the upper nodes. The stem below the flowering spike is curved to lie parallel with the water surface and is about twice the diameter of the lower stem. Floral bracts subtending the pistillate flowers are equal or slightly longer than the flowers.

The following set of characters is used by Aiken (1981) in distinguishing Eurasian watermilfoil from northern watermilfoil:

Stem thickened below the inflorescence to almost double the width of the lower stem, usually curved to lay parallel with the water surface; scales at the inflorescence nodes 2-3, black, distinct in fresh material; plants never forming turions. *Eurasian watermilfoil*

Stem not thickened below the inflorescence, straight; scales at the inflorescence nodes 0-2, black or brown, indistinct; plants forming turions of black green leaves from October to June. *Northern watermilfoil*

Habitat/Growth Characteristics

Eurasian watermilfoil is a highly invasive and aggressive species that colonizes reservoirs, lakes, ponds, streams, small rivers and brackish waters of estuaries and bays. As stems of Eurasian watermilfoil near the water surface, they branch profusely and often form a dense canopy that reduces light availability for ~~"u~~understory" species. *Myriophyllum spicatum* dies back to propagating root crowns during the winter months and does not form turions as does *M. sibiricum*. Spread of Eurasian watermilfoil is primarily by asexual means. Long range dispersal is primarily by fragmentation that results from mechanical breakage or autofragmentation which occurs after flowering and at the end of the growing season. Fragments produced by either method may be transported over long distances by water currents. Fragments may also be transported from one water body to another when fragments become attached to boat trailers. Once established, individual plants may expand for distances of a few meters by the production of stolons. Although Eurasian watermilfoil produces large quantities of viable seed, very few seedlings have been observed in field situations, and seed are considered to be of minor importance in dispersal of *M. spicatum* (Smith and Barko 1990).

Problems

Eurasian watermilfoil may ~~"s~~hade out" and outcompete desirable native species and form monospecific colonies over large areas of some water bodies. Dense mats and colonies of *M. spicatum* can restrict swimming, boating, bank fishing, and negatively impact aesthetic appeal. Fragments and floating mats may clog water intakes at power generation facilities and potable water intakes. Dense stands of Eurasian watermilfoil provide habitat for mosquitoes and may increase populations of some species of mosquitoes (Aiken *et al.* 1979, Smith and Barko 1990). Because of the problems caused by Eurasian watermilfoil, large-scale management programs have been implemented by the Tennessee Valley Authority, the U.S. Army Corps of Engineers, and governmental agencies in Canada.

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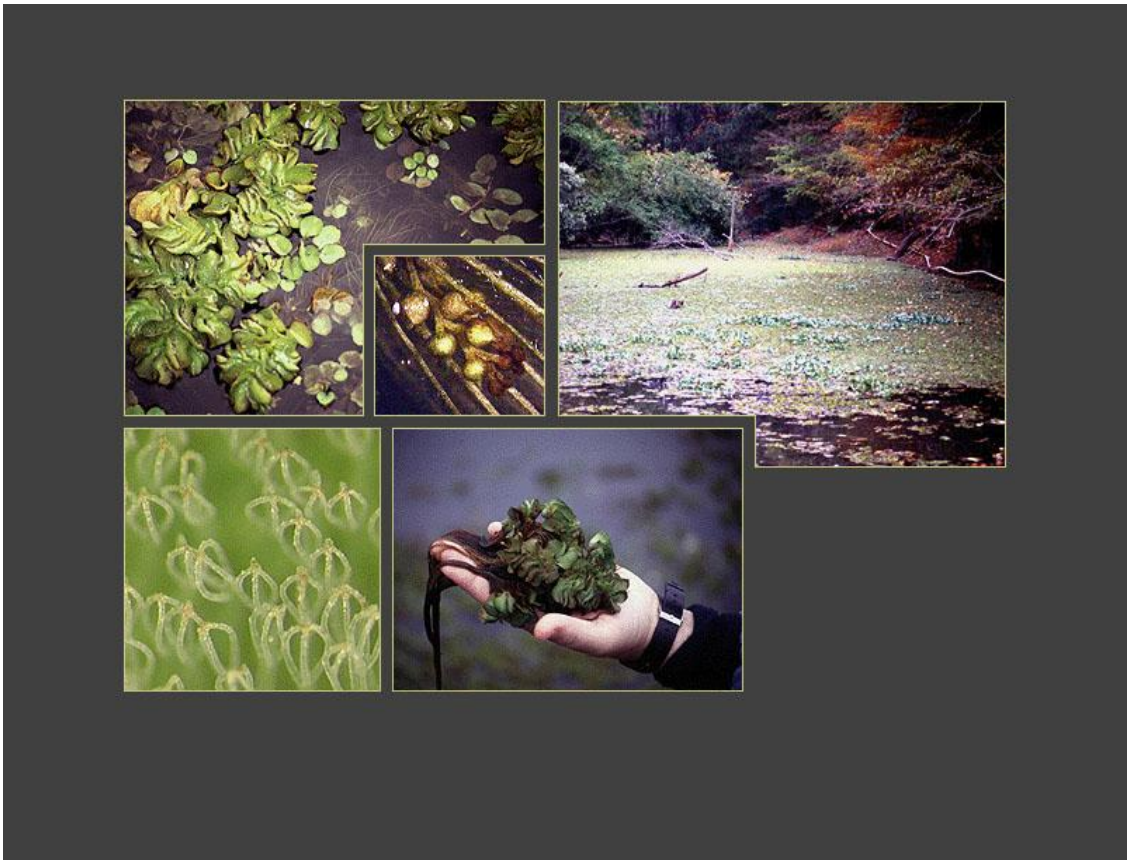
Smith, C. S. and J. W. Barko. 1990. Ecology of Eurasian watermilfoil. Journal of Aquatic Plant Management 28: 55-64.

Giant Salvinia



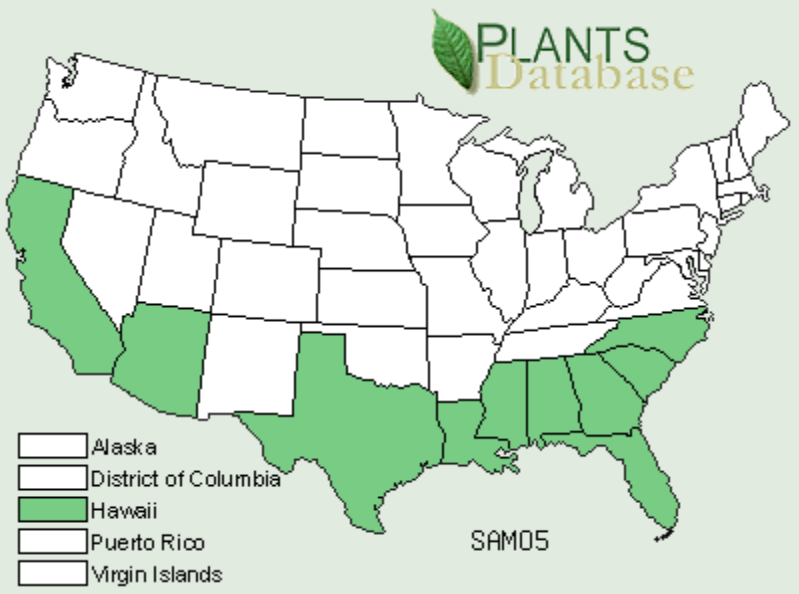
Family

Salviniaceae

Home Range/U.S. Introduction

Salvinia molesta is native to southeastern Brazil. Introduction of the mat forming fern is thought to have arisen from the water gardening and/or aquarium trade where plants are either sold directly or occur as contaminants in water garden stock. Infestations have been reported from several states including Texas, Alabama, Mississippi, Louisiana, Florida, and Hawaii. The predicted range of the plant in the U.S. approximates the current distribution of water hyacinth.

U.S. Range Map



Species Description

Giant salvinia is a free floating aquatic fern. An individual plantlet consists of a horizontal stem that produces two floating leaves (fronds) up to 25 cm long and a highly dissected submerged frond up to 25 cm. The floating leaves are green, sessile to short petiolate, broadly ovate in shape with entire margins. The midrib extends from the base to the apex of the leaf. The upper surface of the floating fronds is covered with parallel rows of hairs that have a characteristic ~~"e~~agelike" structure at the apex. When plants are young, these leaves are small and float on the water surface. As plants age, the floating leaves become crowded and fold against one another resulting in a more vertical leaf position. The brown, feathery submerged leaf resembles and functions as a root. This frond bears the sporocarps or spore forming structures. The globose sporocarps are densely hairy; short stalked and 2-3 mm in diameter. Spores are rarely formed and if present are deformed and infertile.

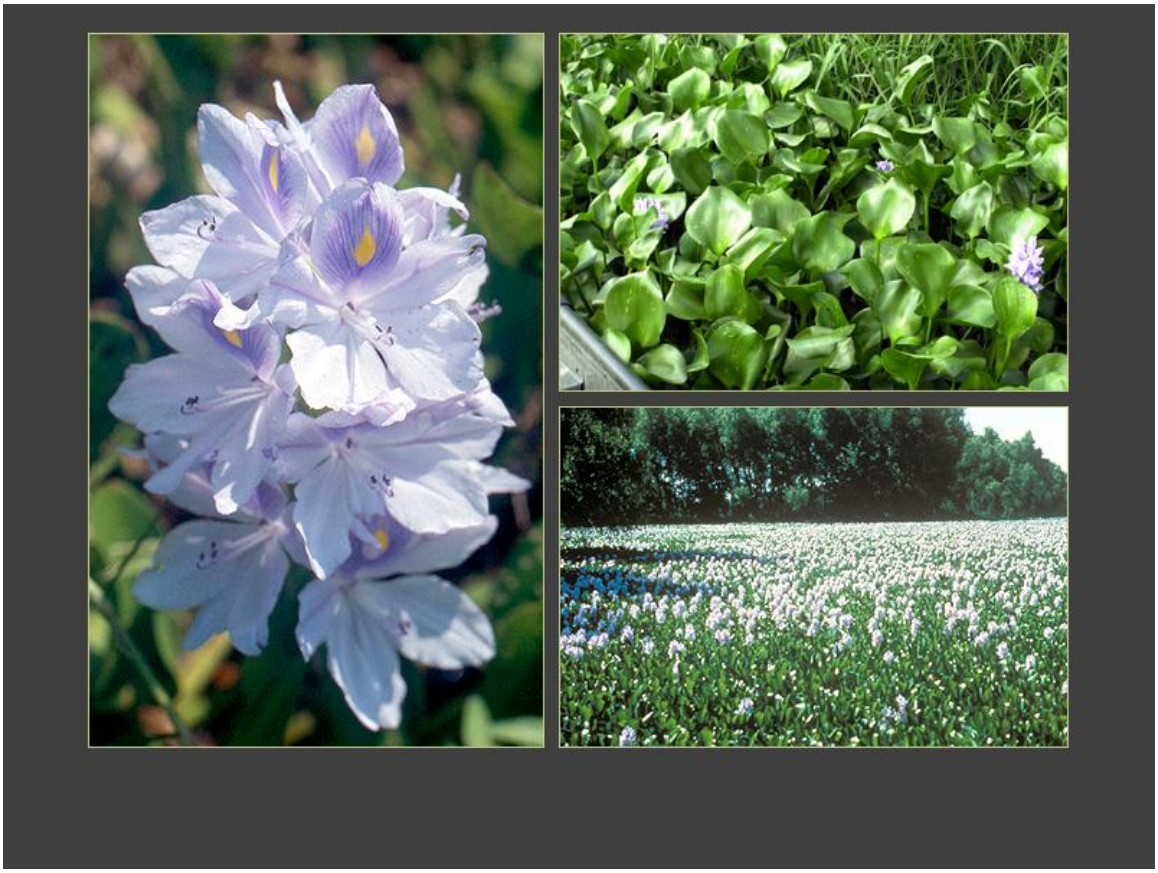
Growth Characteristics

Giant salvinia grows best in stagnant or slow flowing water. Quiet waters of lakes, ponds, bays, oxbows, ditches, swamps, and marshes may be susceptible to invasion. In Ceylon, the species has proven to be problematic in rice fields. The rhizomatous plant can rapidly form dense floating mats of vegetation. Disturbance usually results in fragmentation and any fragment having an axillary bud can give rise to a new plant. The optimum temperature range for growth is 25-28 C and under these conditions plants can double within 1 week.

Problems

Giant salvinia can impact irrigation systems, navigable waters, fisheries, electric power production, and rice farming. Giant mats reduce light penetration and result in oxygen depletion. As light becomes limiting, it affects the growth and survival of phytoplankton and vascular plants. Oxygen depletion may be so severely reduced beneath a mat that it influences fish survival. Extensive mats may exacerbate a situation because they prevent water circulation and mixing.

Waterhyacinth



Synonym(s)

Eichhornia speciosa Kunth
Piaropus crassipes (Mart.) Raf.

Family

Pontederiaceae

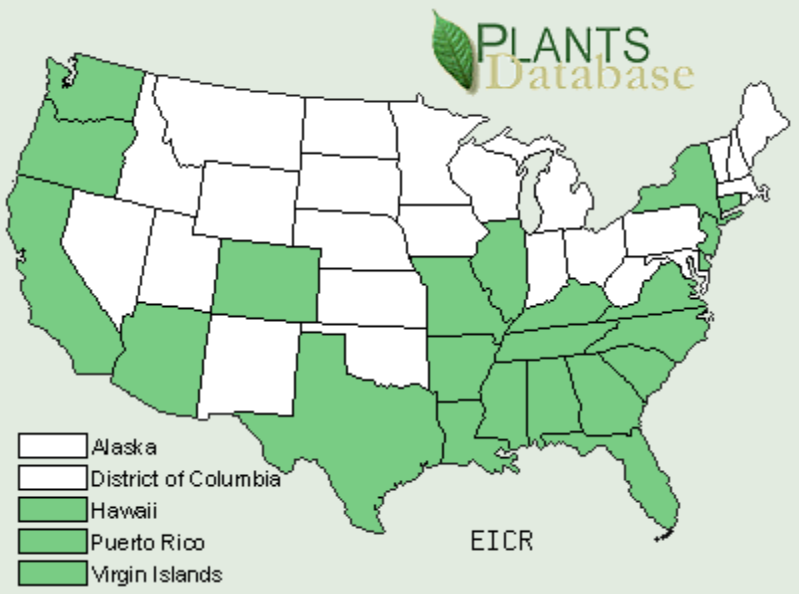
Home Range/U.S. Distribution

Eichhornia crassipes (Mart.) Solms. is native to South America, probably Brazil. Plants are thought to have been first introduced into the United States at the 1884 Cotton States Exposition in New Orleans, Louisiana (Sculthorpe 1967). Because of its showy flowers, waterhyacinth is sold as an ornamental for small fish ponds and sometimes escapes or is intentionally introduced into larger water bodies such

as lakes and reservoirs. The distribution of *E. crassipes* shown on the map in this system depicts where populations are expected to ~~o~~verwinter" and regrow during most years.

Another species of waterhyacinth, *Eichhornia azurea* (Sw.) Kunth, has been introduced into south Texas from Latin America (Correll and Johnson 1970, Tarver *et al*. 1986). It can be distinguished from *E. crassipes* by a lack of inflated petioles and the presence of an obvious stem with leaves along its entire length that are separated by distinct internodes.

U.S. Range Map



Species Description

Waterhyacinth floats on the surface of the water or is sometimes stranded on mud and appears rooted. The individual plants consist of several leaves in rosettes and are connected by stolons. Prominent, black roots hang from each rosette. The leaf petiole is usually inflated, spongy, and up to 20 cm long. The leaf blades are thickened, leathery, 2 to 15 cm long and 2 to 10 cm wide, suborbicular, ovate or broadly elliptic with parallel veins. The leaf bases are heart-shaped, square or rounded the leaf apices rounded to flattened. The inflorescence is a spike with several light-blue to bluish-purple flowers that have a yellow blotch. The fruit is a many seeded capsule.

Habitat/Growth Characteristics

Waterhyacinth grows in ponds, canals, freshwater and coastal marshes, lakes, and back water sloughs and oxbows along rivers. Reproduction is primarily by vegetative means from runners or stolons. This method of vegetative reproduction allows the plant to quickly colonize large areas in relatively short periods of time. During periods of drought, waterhyacinth can survive as seed that remain dormant until reflooding occurs. Because waterhyacinth is free-floating, wind and water currents function to distribute plants within a water body (Tarver et al. 1986). The large, robust plants of waterhyacinth are often referred to a ~~"b~~ull hyacinths". Populations of waterhyacinth are dramatically influenced by climatic conditions, expanding during years with mild winters and contracting or being eliminated from areas of the interior United States during particularly harsh winters.

Problems

Dense growth of waterhyacinth can clog canals and water intakes and restrict navigation along rivers and lakes. It can also negatively impact water quality and exclude native vegetation. Problems caused by this species far outweigh any benefits it provides in natural aquatic and wetland habitats.

References

Correll, D. S. and M. C. Johnston. 1970. Manual of the Vascular Plants of Texas Research Foundation, Renner, Texas.

Sculthorpe, C. D. 1967. The Biology of Aquatic Vascular Plants. St. Martin's Press, New York.

Tarver, D. P., J. A. Rogers, M. J. Mahler, and R. L. Lazor. 1986. Aquatic and Wetland Plants of Florida. Third Edition. Florida Department of Natural Resources, Tallahassee, Florida.

Alligatorweed

Synonym(s)

Alternanthera philoxeroides (Mart.) Standl.

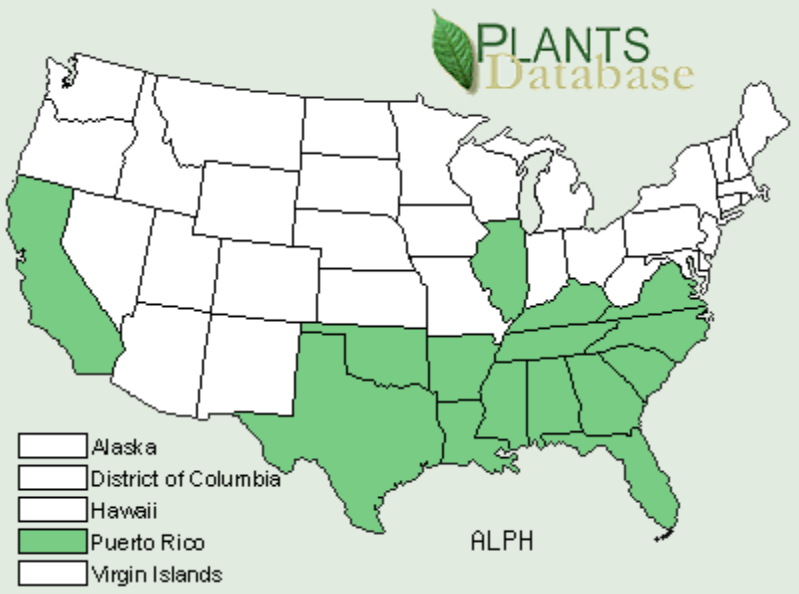
Family

Amaranthaceae

Home Range/U.S. Introduction

Alternanthera philoxeroides (Mart.) Griseb. is native to South America and was introduced into the United States around 1900 (Spencer & Coulson 1976). Alligatorweed is now widely distributed from Virginia to Florida, west to Texas. Populations of the weed also are reported from California.

U.S. Range Map



Species Description

Plants are perennial with stems usually bent toward the bottom and rooting at the nodes. Stems are glabrous except for a narrow band of hairs within the leaf bases. The stems become hollow and slightly flattened with age, often pink when fresh. Leaves are opposite, simple, sessile, usually thick and fleshy, linear-elliptic, to 9 cm long and 1.5 cm wide, apices acute, tipped with a tiny spine, tapering to the base to clasp the stem. One leaf joins with the opposite leaf to form a narrow sheath. The inflorescence is a several-flowered, whitish head on a stalk. Petals are lacking; the sepals are whitish.

Habitat/Growth Characteristics

Alligatorweed grows in ponds, lakes, streams, canals, ditches and wet soil of agricultural lands. The stems form dense, tangled masses in the water or in moist soil along shorelines. Stems may be a several meters long and extend from the shoreline into shallow water. Alligator weed in the United States apparently does not produce viable seed (Spencer & Coulson 1976) and reproduction is vegetative. Each node is capable of producing a new plant.

Problems

Dense mats of alligatorweed may impede flow in irrigation canals, restrict small boat navigation, and hinder fishing and other forms of recreation (Tarver *et al*. 1986, Chester 1988). Biological control of this species with insects has been spectacularly successful; in 1963 there were over 38,800 problem ha in the United

States but in 1981 there were less than 400 ha and all states, except North Carolina, now rely on this method to keep populations at acceptable levels.

References

Chester, E. W. 1988. Alligatorweed, *Alternanthera philoxeroides* (Mart.) Griseb. in Kentucky. Transactions of the Kentucky Academy of Science 49: 140-142.

Spencer, N. R. and J. R. Coulson. 1976. The biological control of alligatorweed, *Alternanthera philoxeroides*, in the Unites States of America. Aquatic Botany 2:177-190.

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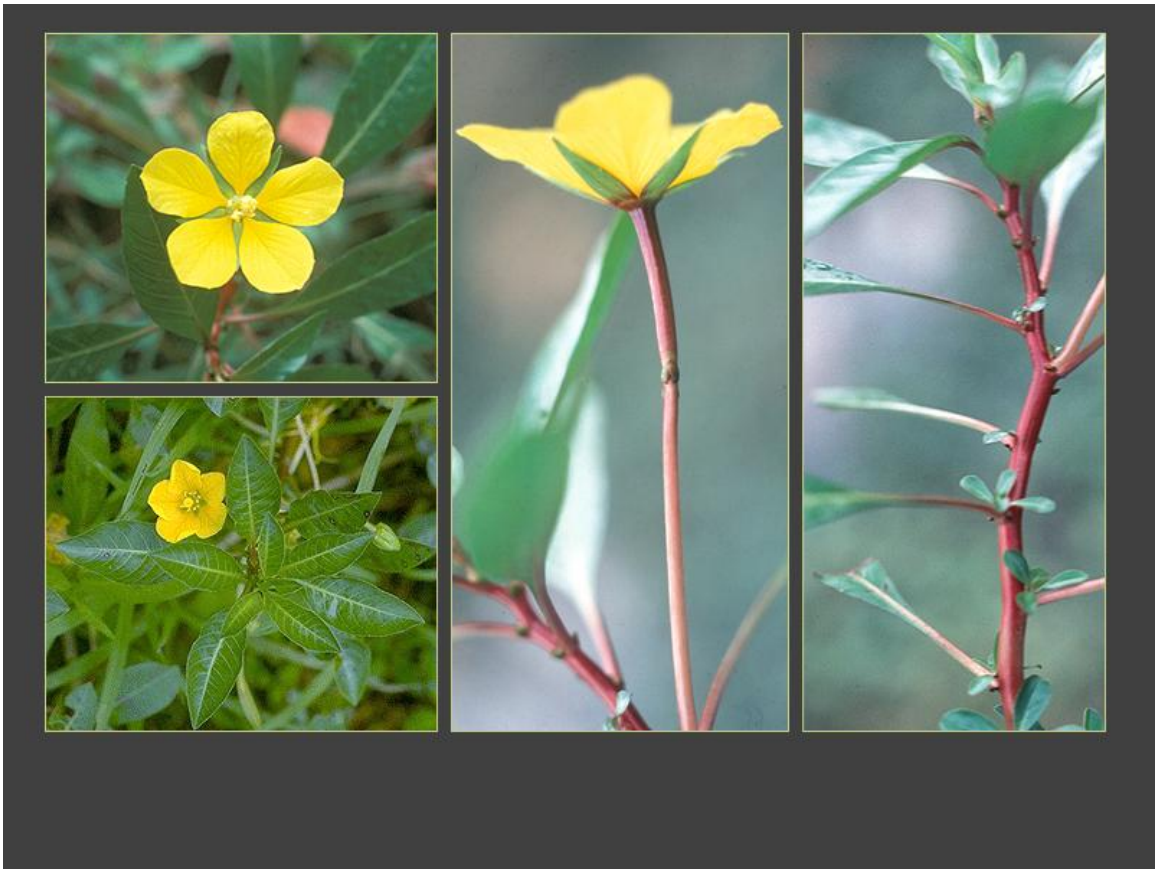
Floating Primrose Willow



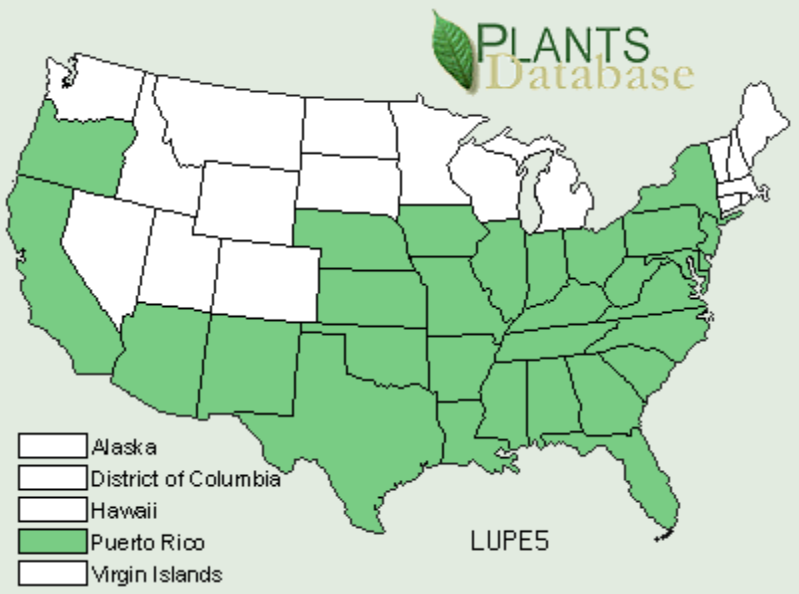
Family

Onagraceae

Home Range/U.S. Introduction

Ludwigia peploides (HBK.) Raven is common in some portions of the southeastern United States and occurs sporadically from eastern United States westward to California. It ranges over much of the warmer portions of the New World including the West Indies, Mexico, and Central and South America. Although most manuals indicate it to be native to the United States, Godfrey and Wooten (1981) note *L. peploides* to be ~~"q~~questionably native" to the southeastern United States. Plants in the southeastern (Godfrey and Wooten 1981) and southwestern United States (Correll and Correll 1975) are considered to be subspecies *peploides*. Some of the older taxonomic treatments place *L. peploides* and several other species of *Ludwigia* in the genus *Jussiaea* L.

U.S. Range Map



Species Description

Creeping water primrose is a creeping or floating aquatic perennial herb that sometimes forms mats. Stems and leaves are usually glabrous or sometimes sparsely pubescent. The leaves are alternate, simple, and net-veined. Leaves of the floating stems are oblanceolate to spatulate, or sometimes orbicular in shape. Stems bearing flowers are usually weakly upright with lanceolate to narrowly elliptic leaves. Leaf petioles are 1 to 5 cm long. Flowers are axillary, perfect, and solitary on stalks 1 to 5 cm long. The five petals of the flower are yellow. The fruit is a cylindrical capsule with numerous seeds. Seeds are ellipsoid, yellowish, and less than 1 mm long.

In general appearance and growth form, *Ludwigia peploides* is similar to *L. uruguayensis* (Camb.) Hara. The erect flowering stems, and long, shaggy hairs along the stem and on the leaves of *L. uruguayensis* are characters that can be used to separate it from *L. peploides* which typically is glabrous to sparsely pubescent and has flowering stems that are weakly ascending.

Habitat/Growth Characteristics

Ludwigia peploides grows in ditches, ponds, slow moving streams, rice fields, and along margins of lakes and reservoirs. It is a fast growing plant that can reproduce by seed and asexually by rooting at the nodes.

Problems

The floating stems of creeping water primrose may form mats in shallow water along shorelines or cover the entire surface of small ponds. Colonies can restrict bank fishing, swimming, and boat access.

References

Correll, D. S. and H. B. Correll. 1975. Aquatic and Wetland Plants of Southwestern United States. Stanford University Press, Stanford, California.

Godfrey, R. K. and J. W. Wooten. 1981. Aquatic and Wetland Plants of Southeastern United States. Dicotyledons. The University of Georgia Press, Athens, Georgia.

Parrotfeather

Synonym(s)

Myriophyllum brasiliense Camb.
Myriophyllum proserpinacoides Gillies ex Hook. & Arn.

Family

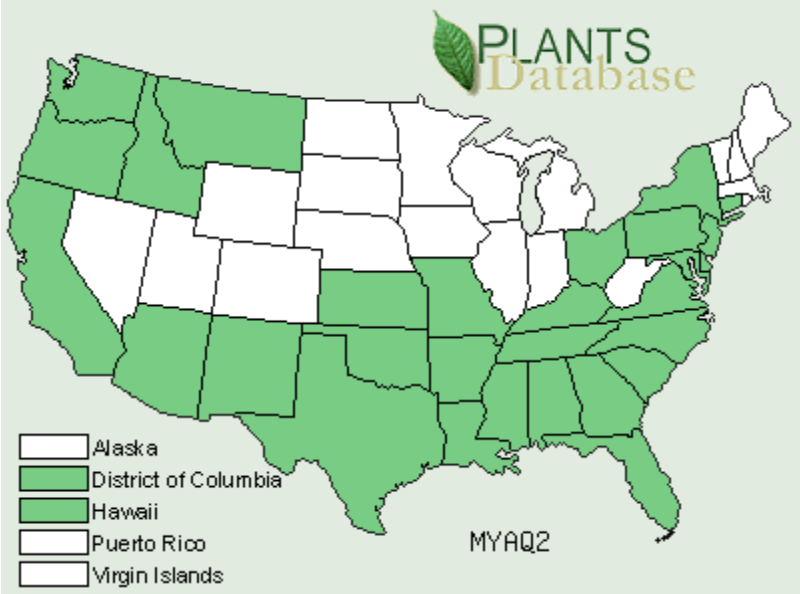
Haloragaceae

Home Range/U.S. Distribution

Myriophyllum aquaticum (Vell.) Verdc. is native to South America. The first known collection of parrotfeather in the United States was in 1890 (Nelson and Couch 1985). Parrotfeather is sporadically naturalized across much of the United States, likely as a result of plants escaping or being discarded from aquaria or ornamental pools. Its spread may have been further enhanced by intentional placement in water bodies to provide a source of plants for sale.

In many of the older manuals and taxonomic literature parrotfeather is referred to as *Myriophyllum brasiliense* Camb., which is a synonym for *M. aquaticum*.

U.S. Range Map



Species Description

The stems of parrotfeather are moderately elongate, relatively stout, partially submersed but with a considerable portion of the leafy branches erect. The leaves are in whorls of 3 to 6, pinnately dissected, stiffish, and with 6 to 18 linear-filiform divisions on each side of the leaf. Leaves on the erect stems are grayish-green, 2.5 to 5 cm long, feather-like, the leaf divisions 4 to 8 mm long toward the leaf apex, reduced basally. Flowers of North American plants all female, whitish and in the axils of essentially unreduced leaves.

Habitat/Growth Characteristics

Parrotfeather grows in sluggish waters, edges of streams, lakes, ponds, irrigation ditches, canals, sloughs, and spring-fed runs. It is rooted in the substrate with part of the stem beneath the surface of the water and a portion of the stem emersed. Parrotfeather forms creeping rhizomes which may give rise to multiple stems. Stems branch and root at the nodes allowing for the formation of fragments. Because only pistillate (female) plants occur in North America, all reproduction is asexual.

Problems

Populations of parrotfeather may become quite dense and completely colonize small ponds and sloughs and impede water flow in drainage ditches and irrigation canals. It may also out-compete and replace native species that are of more value to fish and wildlife.

References

Aiken, S. G. 1981. A conspectus of *Myriophyllum* (Haloragaceae) in North America. Brittonia 33: 57-89.

Nelson, E. N. and R. W. Couch. 1985. History of the introduction and distribution of *Myriophyllum aquaticum* in North America. In: L. W. J. Anderson (ed.), Proceedings of the First International Symposium on watermilfoil (*Myriophyllum spicatum*) and related Haloragaceae species. Aquatic Plant Management Society, Washington, D.C. pp. 19-26.

Flowering Rush

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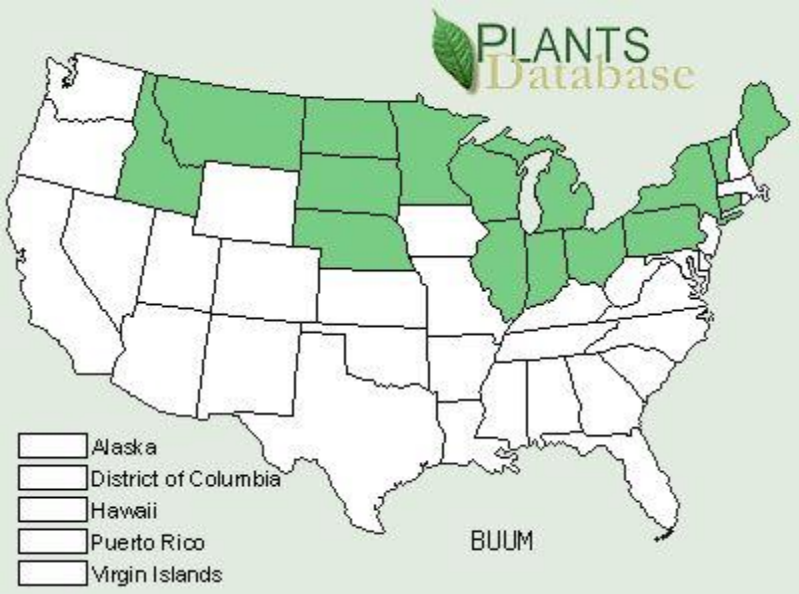
Family

Butomaceae

Home Range/U.S. Introduction

Flowering rush (*Butomus umbellatus L.*), native to Europe and western Asia, was first observed in 1897 on the St. Lawrence River and has since naturalized in several northern states.

U.S. Range Map



Species Description

Perennial herb, rush-like emergent, flowering in mid-summer, or grows submersed in deeper water up to 2m deep or more. Flowers grow in umbrella shaped clusters and each individual flower has 3 whitish pink petals. Plants only produce flowers in very shallow water or on dry sites. Flowering rush has green stems that resemble bulrushes but are triangular in cross section. The leaf tips may be spirally twisted. Along shore, flowering rush has erect leaves and grows to about 3 feet in height. Under water, the leaves are limp.

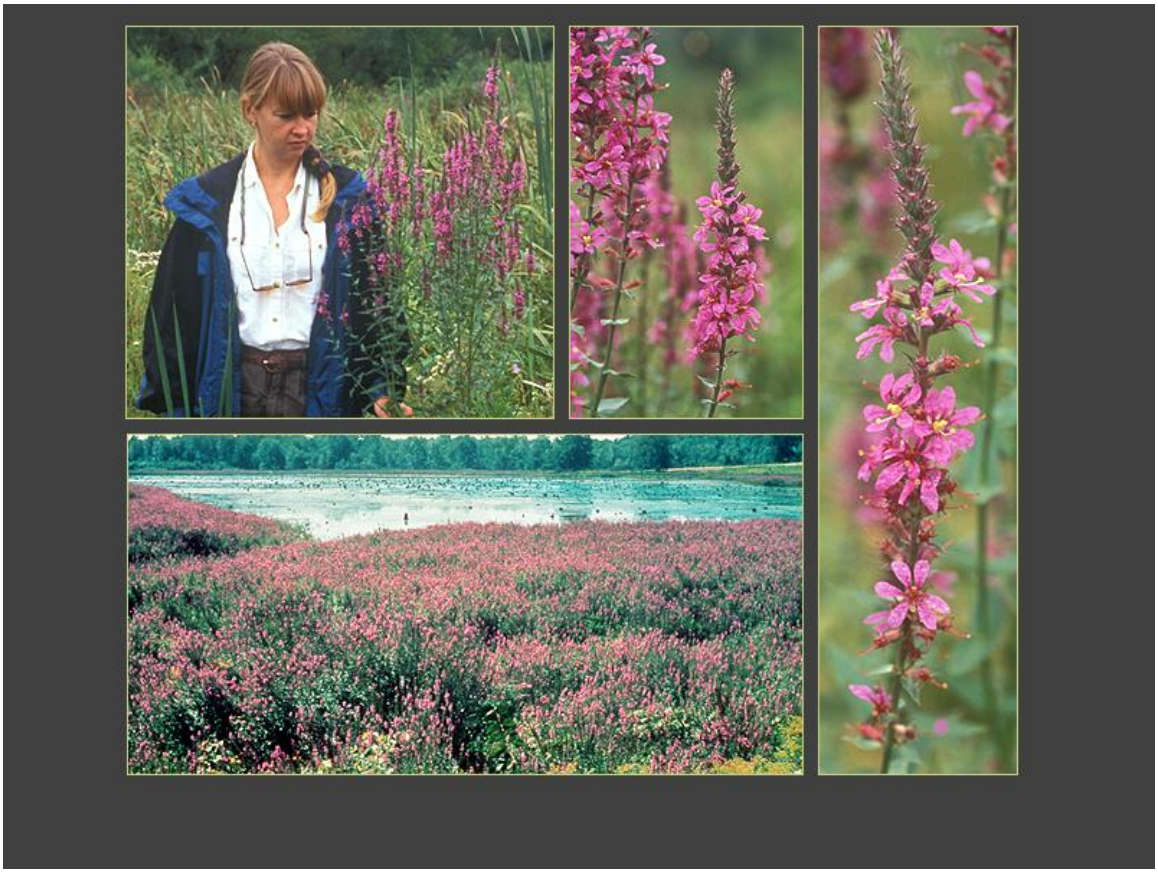
Problems

Flowering rush spreads readily by rhizomes and root pieces. Movement by wildlife is believed to be a vector of spread, as well as unintentional transport by boaters. It is difficult to control with herbicides.

References

(http://www.seagrant.umn.edu/exotics/rush.html)

Purple Loosestrife



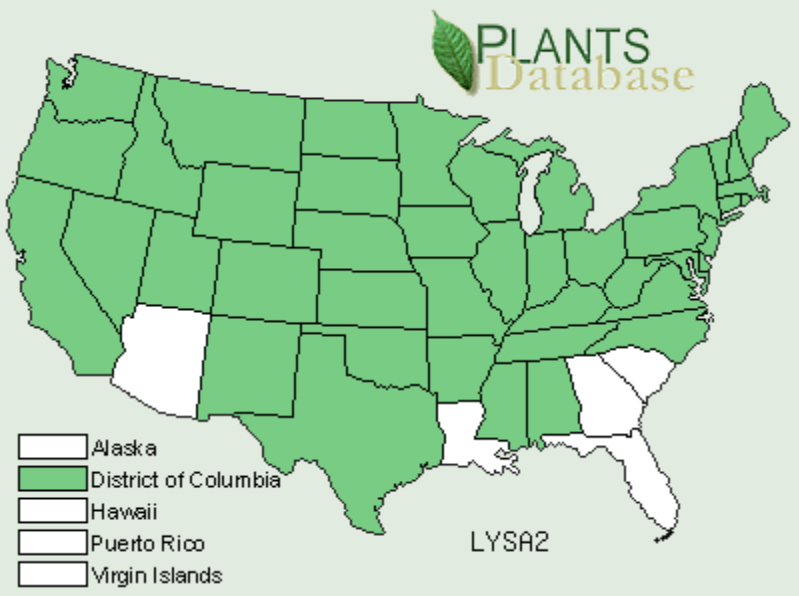
Family

Lythraceae

Home Range/U.S. Introduction

Lythrum salicaria L. is native to Eurasia and is now naturalized over large areas of the United States. It apparently was introduced into coastal areas of the northeastern United States in the early 1800's (Stuckey 1980). Due to its attractive flowers, it has been planted as an ornamental garden species and has escaped from cultivation; it is now in at least 40 states and Canada.

U.S. Range Map



Species Description

Plants are erect, emersed, much-branched perennials, glabrous to often pubescent, growing to 2 m tall. The stems are 4-angled. The leaves are opposite or whorled, sessile, mostly longer than the internode above, 2 to 10 cm long, 0.5 to 1.5 cm wide, and the base obtuse to cordate. Flowers are whorled in showy terminal bracteate spike-like inflorescences. The 6 petals are rose-purple, up to 10 mm long. There are usually 12 stamens.

Habitat/Growth Characteristics

Purple loosestrife grows in marshes, along pond, lake and river margins, canals, wet meadows, prairies and ditches. The plant regrows from a strong root stock, and a single plant can produce 2.5 million seeds annually (Malecki *et al*. 1993). In many wetland areas purple loosestrife produces large colonies.

Problems

Populations of purple loosestrife often spread so aggressively that native vegetation is suppressed and the structure and function of wetlands are altered (Thompson *et al*. 1987) and the value of wetlands for wildlife is reduced. Purple loosestrife may also degrade the quality of pasture and hay (Thompson *et al*. 1987) and impede the flow of water in irrigation canals (Malecki *et al*. 1993). It is estimated that 200,000 ha of wetlands in the United States are degraded annually through invasion of purple loosestrife.

References

Malecki, R. A., B. Blossey, S. D. Hight, D. Schroeder, L. T. Kok, and J. R. Coulson. 1993. Biological control of purple loosestrife. Bioscience 43(10):680-686.

Stuckey, R. L. 1980. Distributional history of *Lythrum salicaria* (purple loosestrife) in North America. Bartonia 47:3-20.

Thompson, D. Q., R. L. Stuckey, and E. B. Thompson. 1987. Spread, impact, and control of purple loosestrife (*Lythrum salicaria*) in North American wetlands. U.S. Fish and Wildlife Research Report 2.

Giant Reed

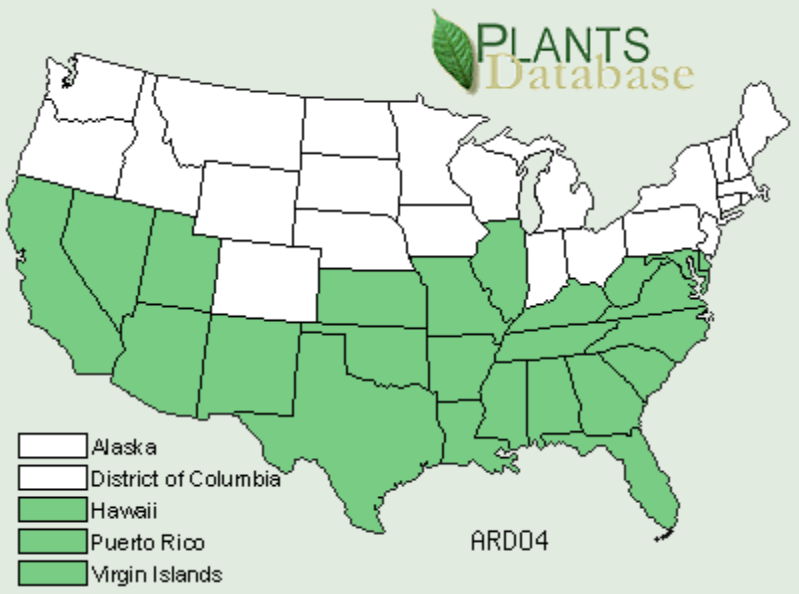
Family

Poaceae

Home Range/U.S. Introduction

Giant reed (*Arundo donax* L) is a native of Europe and has become naturalized throughout southern United States.

U.S. Range Map



Species Description

Giant reed is a perennial clump-forming grass that can attain heights of 7-8 meters. The leaves are chiefly cauline, long tapering to a sharply acute tip. The blades are flat 2-6 cm wide with scabrous margins. The ligule is membranous and minutely ciliate. The panicles are large and plumy and may reach a length of 0.6 m. Long hairs on the lemmas give the plumes a feathery appearance.

Growth Characteristics

Giant reed grows rapidly and can readily propagate from rhizomes, thereby forming tall dense stands. Fertile caryopses seldom develop. The grass commonly invades areas along streambeds.

Problems

Giant reed easily displaces native species and forms monospecific stands along waterways. These monocultures consume more water than native plants; create flood-control problems, and the large biomass that dies back each season creates a fire hazard.

Common Reed

Synonym(s)

Phragmites communis Trin.
Phragmites phragmites (L.) Karst.

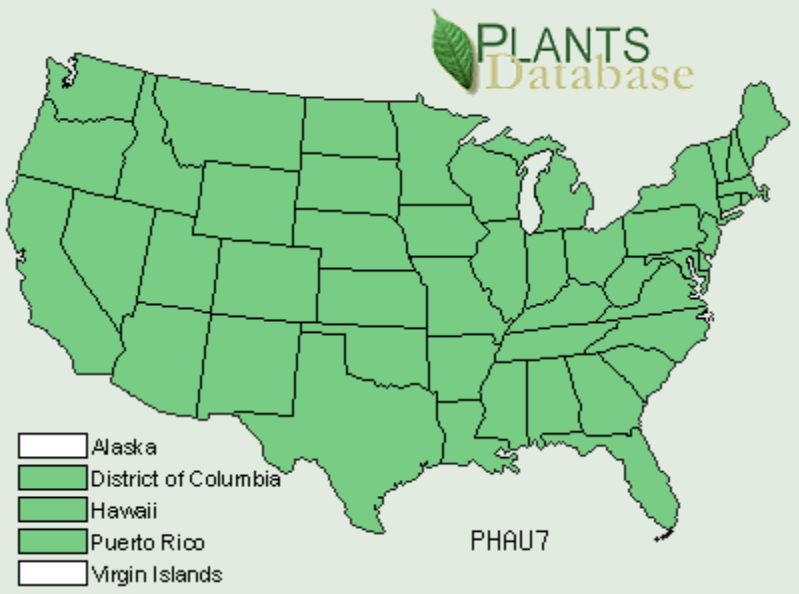
Family

Poaceae (Gramineae)

Home Range/U.S. Introduction

Phragmites australis (Cav.) Trin. ex Steud. is widespread in temperate and tropical regions of the world and is native to the United States (Gould 1968).

U.S. Range Map



Species Description

Common reed is a tall, coarse perennial with stout rhizomes to 2 cm across, deep seated in the substrate. Stems are up to 4.5 m tall, 5 to 15 mm thick, leafy throughout, the sheaths overlapping with a large, dense, terminal panicle. The leaves are flat, stiff, 1 to 6 cm broad and up to 6 dm long, tapering to long-attenuate tips. Leaf margins are serrate. The ligule is a ring of dense short stiff hairs. The panicle is terminal, plume-like, tawny to purplish or silvery, 15 to 50 cm long, 2 dm broad, with many branches. The flowers have long, silky hairs.

Habitat/Growth Characteristics

Phragmites is found in marshes and in shallow water along the shoreline of lakes, ponds, swamps, ditches, streams, canals, rivers, and estuaries. It may produce large quantities of seed, but in many cases very few are viable. The seed will not germinate in more than about 5 cm of water (Marks *et al*. 1994). Once established, *Phragmites* spreads by rhizomes and stolons and often forms dense, monospecific colonies along shorelines and shallow water areas. Rhizomes are reported to grow up to about 2 m per year and be as long as 20 m (Batterson & Hall 1984).

Problems

Dense colonies of common reed may impede water flow, recreational activities such as fishing, and restrict view from shoreline areas (Tarver *et al.* 1986). In some parts of the world, *Phragmites* is cultivated for the production of fiber and is

sometimes used in constructed wetlands for the removal of nutrients and pollutants (Batterson & Hall 1984).

References

Batterson, T. R. and D. W. Hall. 1984. Common reed - *Phragmites australis* (Cav.) Trin. ex Steudel. Aquatics 6(2): 16-17, 20.

Gould, F. W. 1968. Grass Systematics. McGraw-Hill, Inc., New York

Marks, M, B. Lapin, and J. Randall. 1994. *Phragmites australis* (*P. communis*): Threats, management, and monitoring. Natural Areas Journal 14(4): 285-294.

Tarver, D. P., J. A. Rogers, M. J. Mahler, and R. L. Lazor. 1986. Aquatic and Wetland Plants of Florida. Third Edition. Florida Department of Natural Resources, Tallahassee, Florida.

Saltcedar

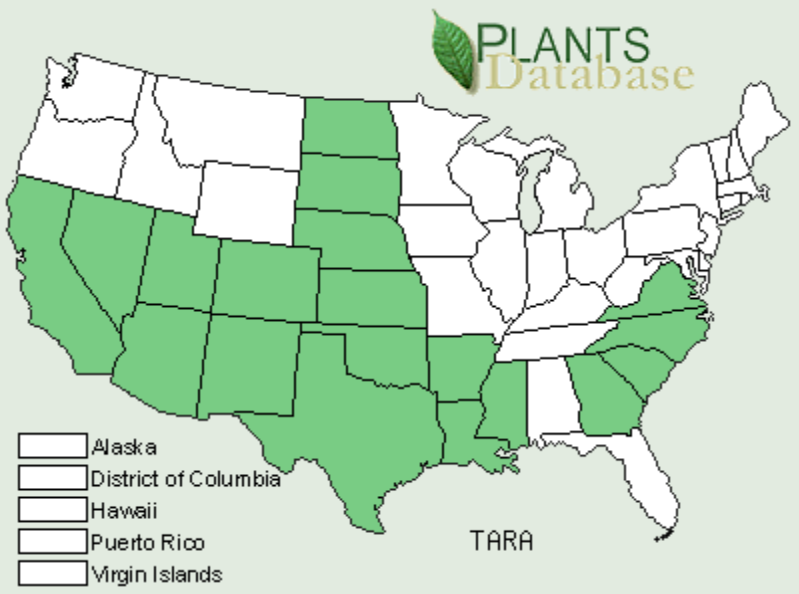
Family

Tamaricaceae

Home Range/U.S. Introduction

The genus *Tamarix* consists of about 50 species in the Old World, several of which are cultivated in the United States as ornamentals (Correll and Johnston 1970; Correll and Correll 1975). Salt cedar also is sometimes planted as a wind break and for stabilizing sand and sandy soils. Species of salt cedar are very much alike, and in many instances difficult to distinguish without examining minute characteristics of the flowers under high magnification (20X). According to Baum (1967), the most common species of *Tamarix* in the United States are *T. chinensis* Lour. (Chinese tamarisk), *T. parviflora* DC., *T. ramosissima* Ledeb., *T. gallica* L. (salt cedar), *T. africana* Poir., and *T. aphylla* (L.) Karst. If species determination is required, a regional flora manual or Baum (1967) should be consulted.

U.S. Range Map



Species Description

The species of *Tamarix* are shrubs or small trees with irregularly spreading-ascending, elongate branches with leafy branchlets that are very slenderly flexuous. The leaves are alternate, small, scale-like, a few millimeters long, sessile, broadest basally and more or less clasping or sheathing. Leaves are usually deciduous but may persist through mild winters. Flowers are small, short-pediceled or sessile with 4 or 5 pink or white petals inserted under a staminal disk. The fruit is a capsule that opens into 3 to 5 valves. Seeds are minute, densely bearded, or rarely winged.

Some species of salt cedar resemble opposite or whorled-leaved *Juniperus* (juniper or redcedar) but can be distinguished by the alternate leaves of *Tamarix*.

Habitat/Growth Characteristics

Several species of *Tamarix* have become naturalized along rivers, streams, irrigation ditches, around lakes, coastal areas, salt flats, and waste places. Salt cedar can tolerate saline and alkaline conditions and is often found in such areas.

Problems

These trees and shrubs provide shade and are excellent providers of nectar, which is important in the production of honey. However, in many regions they have become a serious problem because they form extensive stands and cause great water loss. In some areas of the southwestern United States and California, native

plant communities have been displaced and desert wetlands have been desiccated. Native vegetation on some islands of the Gulf also has been eliminated or greatly reduced by the abundance of salt cedar (Duncan & Duncan 1988).

References

Baum, B. R. 1967. Introduced and naturalized tamarisks in the United States and Canada (Tamaricaceae). Baileya 15:19-25.

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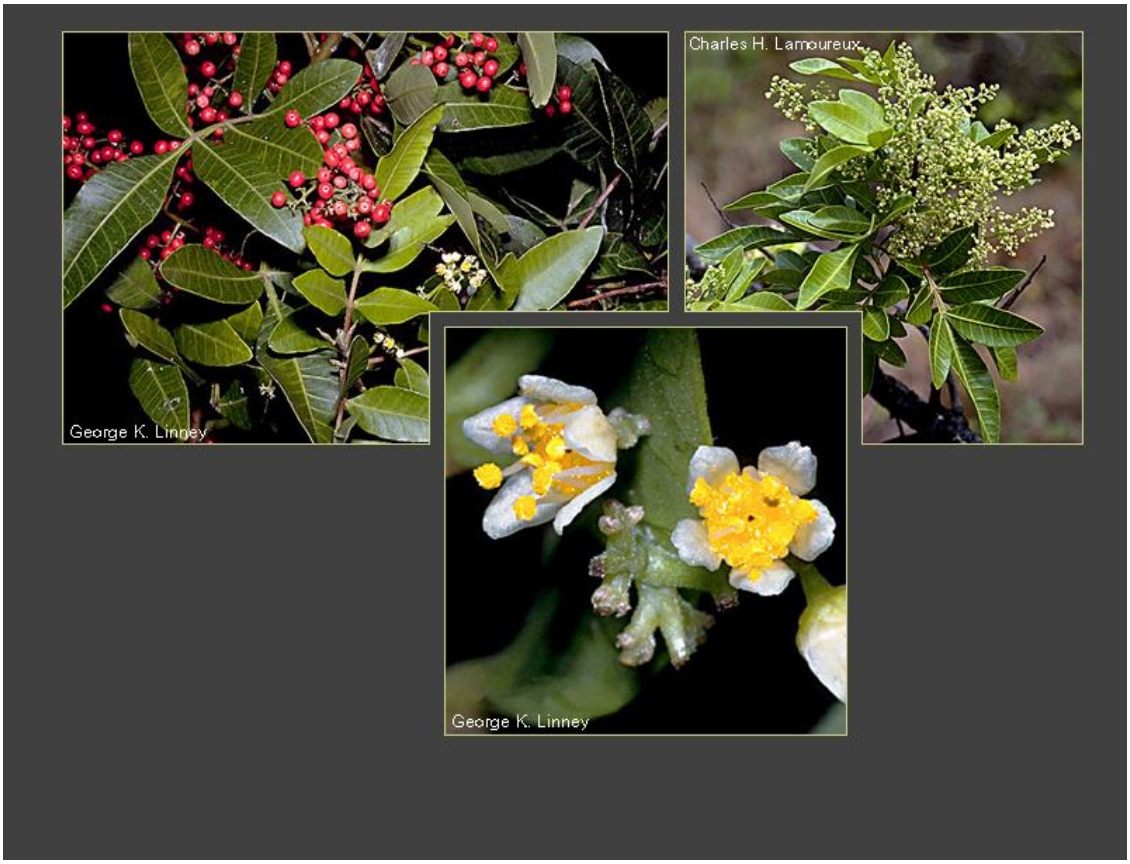
Correll, D. S. and M. C. Johnston. 1970. Manual of the Vascular Plants of Texas. Texas Research Foundation, Renner, Texas.

Duncan, W.H. and M.D. Duncan. 1988. Trees of the Southeastern United States. The University of Georgia Press, Athens, Georgia.

Brazilian Pepper



Family

Anacardiaceae

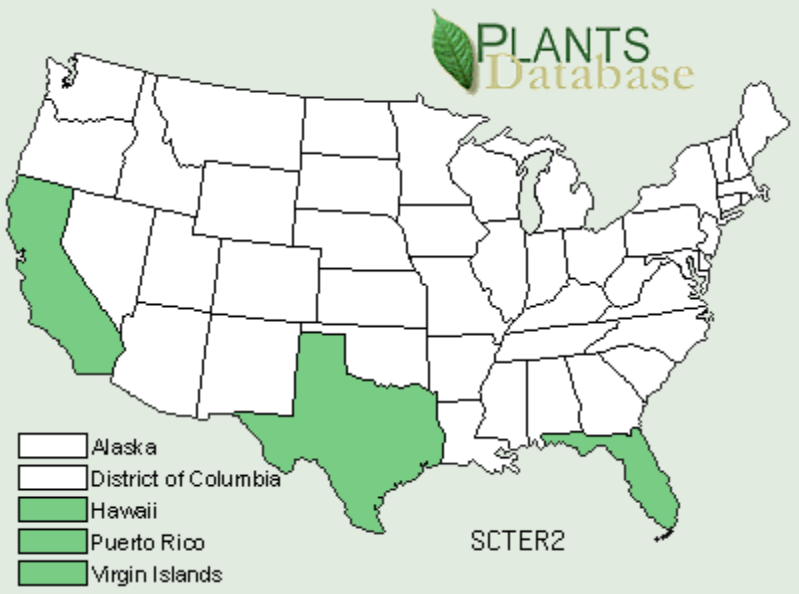
Other Common Names

Christmas Berry

Home Range/U.S. Introduction

Brazilian pepper (*Schinus terebinthifolius* Raddi) is native to Argentina, Paraguay, and Brazil. In the United States, it has been introduced into Florida, Texas, and California as well as Hawaii, Puerto Rico and the Virgin Islands.

U.S. Range Map



Species Description

Brazilian pepper is a dioecious shrub or small tree reaching 10 meters. The short trunk is topped by a dense growth of contorted intertwining branches. The alternate leaves are compound with 3-13 sessile, oblong finely toothed leaflets. The rachis is distinctly winged. When crushed, the leaves smell of turpentine. The white flowers are very small and develop in tightly branched terminal and axillary clusters. The fruit is a bright red globose drupe.

Growth Characteristics

The semitropical to tropical shrub invades hammocks, pine flatlands, and mangrove forest communities. The seeds are easily dispersed by birds and mammals and retain high viability for several months.

Problems

Brazilian pepper is an aggressive invader that out-competes and displaces native plants. It readily forms monocultures, thereby destroying the native ecologically productive communities.

Eleagnus spp.
Russian Olive
Autumn Olive
Cherry Silverberry

Family

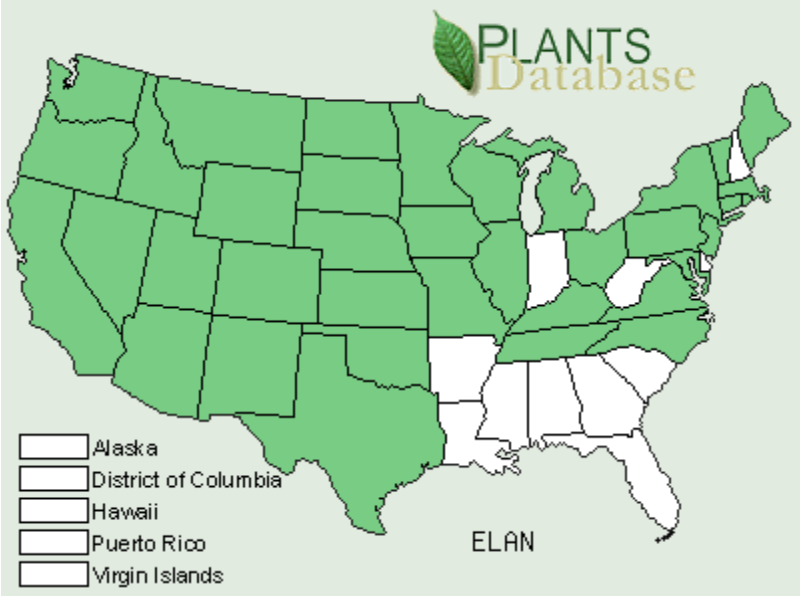
Elaeagnaceae

Home Range/ U.S. Introduction

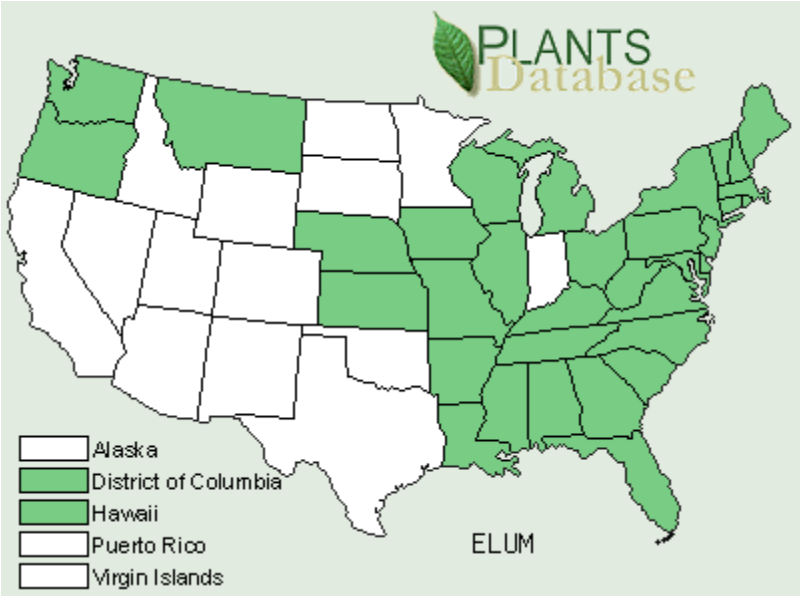
Russian olive, autumn olive, and cherry silverberry all native to either Europe or Asia have been introduced into the United States and have become persistent and/or escaping and becoming naturalized. Russian olive is found primarily in the central and western U. S., as well as in the East where it occurs with autumn olive. In the West, Russian olive occurs mainly in the Great Basin Desert and is also abundant in riparian zones of the Great Plains. Cherry silverberry is found from Missouri east to the Atlantic coast.

U.S. Range Map

Elaeagnus angustifolia



Elaeagnus umbellata



Generic Description

The *Elaeagnus* species described herein are small trees to many branched shrubs. Young branches are often covered with a silvery gray or golden-brown hairy pubescence but with age develop a scaly gray-brown bark. In some species the branches are armed with spines. The ovate to lanceolate leaves are alternate,

petioled, and densely covered with a silvery, scaly or stellate pubescence. The fragrant flowers are solitary or in small clusters of one to three on twigs of the current year. The perfect flowers lack petals but have 4 spreading sepals that are yellowish on the interior surface and white to silvery on the outside, 4 stamens and a single pistil. The fruit is a mealy drupelike achene, round to ovoid, densely covered with a silvery gray pubescence.

Growth Characteristics

Many *Elaeagnus* spp. are capable of nitrogen fixation and have been recommended for companion planting because of this characteristic. Plants are capable of flowering and producing fruit after reaching only three years of age. The yellowish fragrant flowers appear in June and July and are later replaced by abundant silvery fruit. Bird species are probably the primary vector for dispersal although raccoons, skunks, and opossums also feed on the fruit. Some vegetative propagation has been reported. Once established, *Elaeagnus* spp. are highly invasive and difficult to control. They are found in disturbed areas, successional fields, pastures, roadsides, and shelter belts where they have been widely planted. They also have escaped to invade prairies, open woodlands, and forest edges.

Problems

The fast growing persistent habit allows *Elaeagnus* spp. to outcompete native plants, interfere with natural plant succession and nutrient cycling, and reduce water reserves in the soil. The species are drought tolerant and their nitrogen fixing ability allows them to grow in a wide range of soils. Plants can resprout vigorously following cutting or burning.

Russian Knapweed

http://www.cdfa.ca.gov/phpps/ipc/weedinfo/acroptilon-repens.htm

Family

Asteraceae

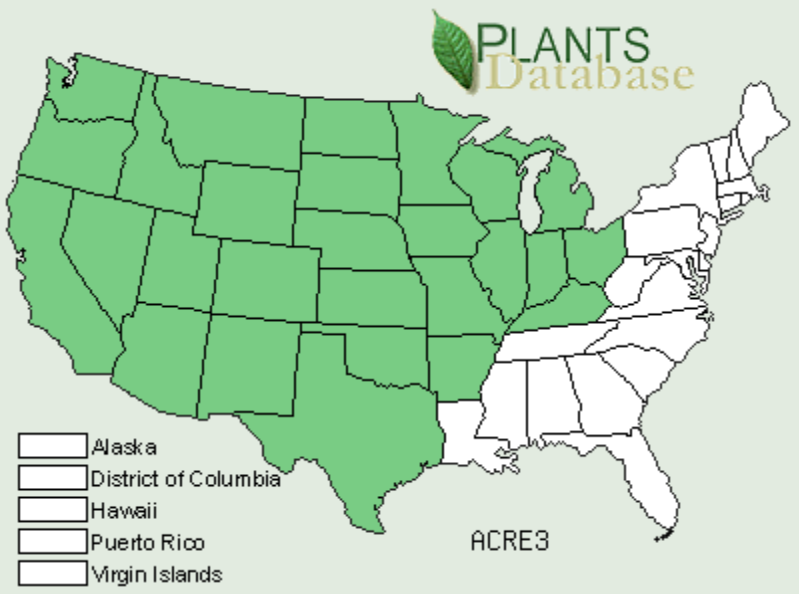
Synonym

Centaurea repens

Home Range/U.S. Introduction

Russian knapweed (*Acroptilon repens*), native to Eurasia, was introduced into North America in the late 1800's. Absent only from southeastern U.S., it has become widespread in other regions.

U.S. Range Map



Species Description

Russian knapweed is a bushy rhizomatous perennial, up to 8 dm tall. Stems and leaves are finely arachnoid-tomentose becoming glabrous and green with age. The rosette leaves are oblanceolate, pinnately lobed to entire, 2-3 cm wide by 3-8 cm long. The lower cauline leaves are smaller, pinnately lobed; the upper leaves become much reduced, sessile, serrate to entire. The heads are numerous terminating the branches. Flowers are pink to purplish, the marginal ones not enlarged. The outer and middle involucral bracts are broad, striate, and smooth with broadly rounded tips; the inner bracts are narrower with hairy tips. Pappus present with bristles 6-11 mm long. Fruit is a whitish, slightly ridged achene.

Growth Characteristics

Russian knapweed is a deep-rooted long lived perennial. Some stands have been in existence for 75 years. It forms dense colonies in cultivated fields, orchards, pastures, and roadsides.

Problems

The plant infests over 600,000 ha in nine western states and 2 Canadian provinces. It has recently become a problem in winter wheat fields. Once established, it is difficult to eradicate. It is poisonous to horses causing ~~"c~~hewing disease".

Spotted Knapweed

http://www.cdfa.ca.gov/phpps/ipc/weedinfo/centaurea-maculosa.htm

Family

Asteraceae

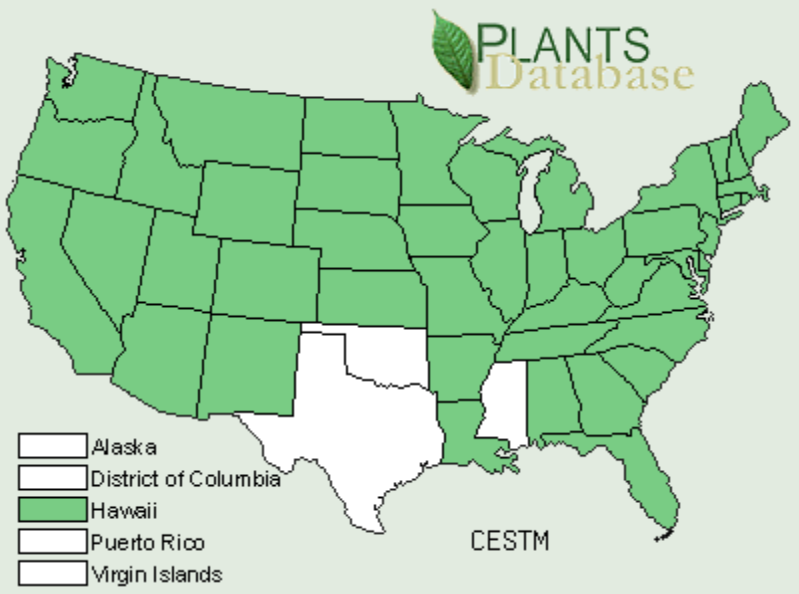
Synonym

Centaurea maculosa

Home Range/U.S. Introduction

Spotted knapweed (*Centaurea biebersteinii*) was introduced from Eastern Europe in the early 1900's as a contaminant in crop seed. It has become widespread in northern and western U.S. and in Canada.

U.S. Range Map



Species Descriptions

Spotted knapweed is a biennial or short lived perennial with a stout taproot. The plant grows 3-12 dm tall having multiple branching stems that are smooth to scabrous. The leaves are pinnatifid with narrow lobes, scabrous puberulent and usually arachnoid-tomentose. Upper leaves may become linear and entire. The pink to light purple flowers are in solitary heads terminating the branches. The involucral bracts are stiff, striate; the outer and middle ones having short dark pectinate tips. Pappus up to 3 mm long. The fruit is a brown or blackish achene with longitudinal lines, glabrous or sparsely pilose.

Growth Characteristics

Spotted knapweed is an aggressive plant that rapidly invades pastures, rangeland, dry meadows, flood plains, roadsides and any other dry, gravelly or sandy sites. Early spring growth makes knapweeds very competitive for soil moisture and nutrients.

Problems

Seeds are produced prolifically and remain viable for a number of years. Infestations crowd out desirable native vegetation. Rangelands are severely impacted because grazing animals pass over knapweed in favor of native grasses and herbs. Hence it is the number one rangeland weed in Montana.

Diffuse Knapweed

http://www.cdfa.ca.gov/phpps/ipc/weedinfo/centaurea-diffusa.htm

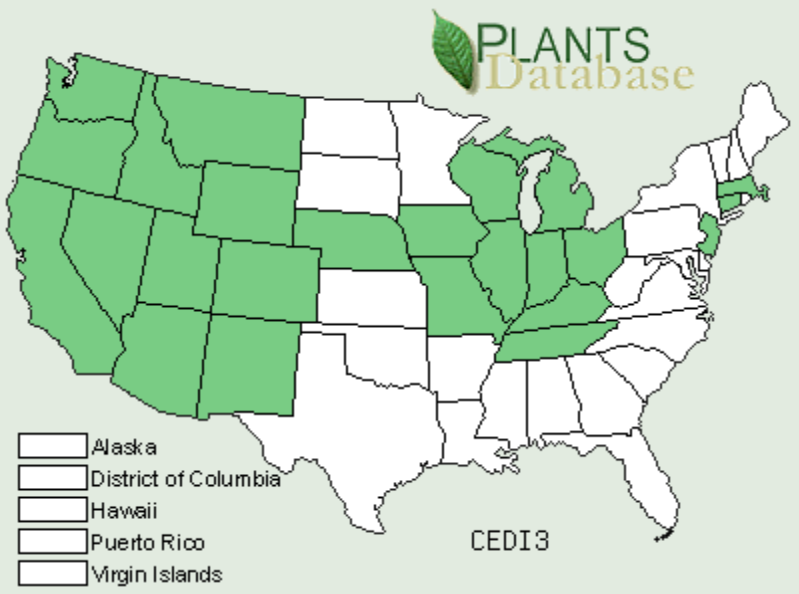
Family

Asteraceae

Home Range/U.S. Introduction

Diffuse knapweed (*Centaurea diffusa*) is native to Eurasia. Introduced into North America in the late 1800's, it is naturalized across western United States and has a scattered distribution in the midwestern and northeastern states.

U.S. Range Map



Species Description

Diffuse knapweed is an annual or biennial herb with a taproot. The stems are erect, 1-6 dm tall, highly branched, angled, scabrous to puberulent. The basal leaves are early deciduous, obovate, pinnatifid, and covered with a thin tomentum; the cauline leaves are alternate, pinnatifid to entire and becoming much reduced toward the plant apex. Flowers are in discoid heads (lack strap shaped petals); corollas white or creamy to purplish. Involucral bracts are stiff, glabrous with an apical spine 1.5-7 mm long with 4-6 pairs of shorter lateral spines. The fruit is a small brown, usually glossy, achene. Pappus absent or greatly reduced.

Growth Characteristics

Reproduction is exclusively by seed. Being allelopathic, it can dominate disturbed areas almost to the exclusion of other species. It can be distinguished from spotted knapweed which it closely resembles by its spine tipped involucral bracts.

Problems

By the late 1980's, 1.3 million ha were infested with diffuse knapweed in western U.S. It rapidly invades overgrazed rangeland and other disturbed sites, and is capable of establishing in undisturbed communities. The foliage contains cnicin and is highly unpalatable resulting in overgrazing of remaining vegetation in rangelands where diffuse knapweed has become established.

Leafy Spurge

Family

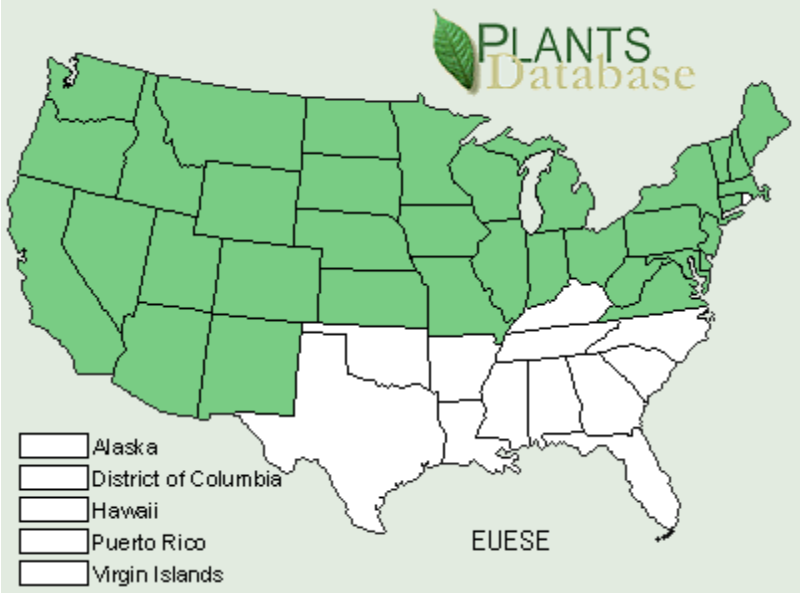
Euphorbiaceae

Home Range/U.S. Introduction

Leafy spurge (*Euphorbia esula* L) is a native of Eurasia. The first record of its presence in North America was in Massachusetts in 1827. By the early 1900s, plants were in the Western U.S. and Canada.

There are many species of *Euphorbia* in North America. Diagnostic characters are found in the number and shape of the glands or appendages of the involucre, the number of staminate flowers in the cyathium and the structure of the seed. Most of these are scarcely observable under 10x magnification. If specific delineation of members of this genus is desired, it would be best to consult a regional manual for help.

U.S. Range Map



Species Description

Plants are perennial from a deep root with slender creeping rootstocks. The stem is glabrous, containing milky acrid juice, usually with numerous alternate flowering branches below the umbel. The leaves are alternate, broadly linear to narrowly lanceolate-oblong, 3-7 cm long, <1 cm wide, essentially 1-nerved, apices obtuse to mucronate. The leaves subtending the umbel are shorter and broader, lanceolate to ovate. The umbel is comprised of 7 or more rays subtended by a whorl of leaves. The inflorescence is termed a cyathium but appears as a single flower with an involucre resembling a calyx or corolla with united lobes. The involucre has 1-5 nectar-bearing glands on its margin; these are strongly 2-horned. There are greenish-yellow petal-like appendages from beneath the glands. The capsule is warty, ca. 5 mm high; seeds are smooth, round-obovoid, 2 mm long.

Growth Characteristics

It is reported that the roots of this species may be up to 5 m deep. It is widely spread in grazing lands. Plants reproduce by rhizomes and seeds which, when ripe, are dispersed up to 5 m from the parent plants. It is believed that water and animals also disperse the seeds.

Problems

This species tends to outcompete other species. It is reported to occupy more than 1 million ha of land. The plants contain a milky juice that is an irritant to some animals.

Yellow Starthistle

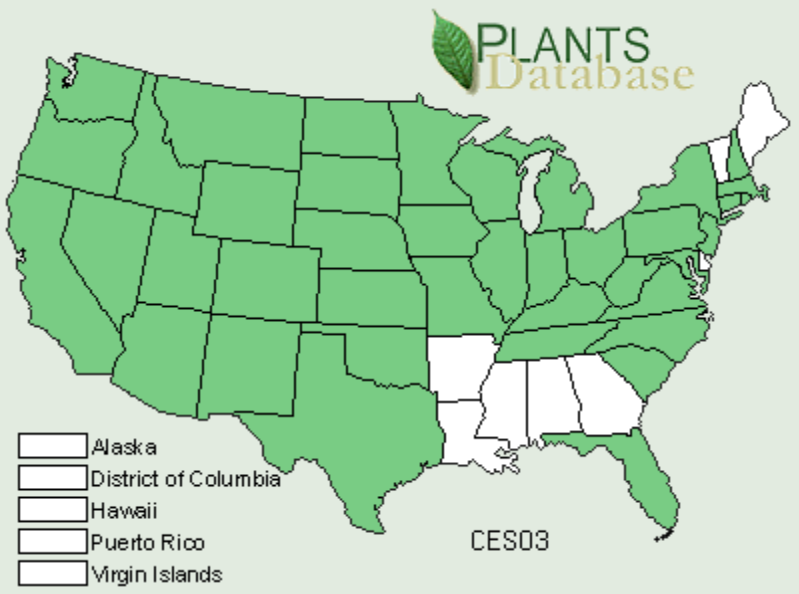
Family

Asteraceae

Home Range/U.S. Introduction

Yellow starthistle (*Centaurea solstitalis*), native of Eurasia, was introduced into western North America in the mid 1800's and has become naturalized across most of the U.S. Highest densities occur in California, Oregon, Washington, and Idaho.

U.S. Range Map



Species Descriptions

Yellow starthistle is a gray-green to blue-green annual or biennial with a deep taproot. The stems are erect, 2-10 dm tall, freely branching, covered with a thin tomentum and prominently winged by decurrent leaf bases. The basal leaves are lyrate or pinnatifid, early deciduous, 4-5 cm wide to 20 cm long; middle and upper leaves are smaller becoming linear and entire. The yellow flowers are in heads that terminate the branches. The middle and outer involucral bracts are spine tipped, the larger central spines commonly 11-30 mm long; inner bracts unarmed. Pappus lacking on marginal flowers, that of others 3-5 mm long. The fruit is a yellowish achene with brown marbling.

Growth Characteristics

The plant develops a deep taproot allowing it to proliferate on dry sites. It reproduces exclusively be seed, estimated to be as high as 29,000 seeds per square meter with about 95% viability. Yellow starthistle frequents fields, roadsides, rangelands, pastures, and waste areas.

Problems

Yellow starthistle is a rapid colonizer that can form dense stands. Production of allelochemicals prevents growth of other plant species. It is poisonous to horses, causing the nervous disorder ~~–e~~hewing disease".

Perennial Pepperweed

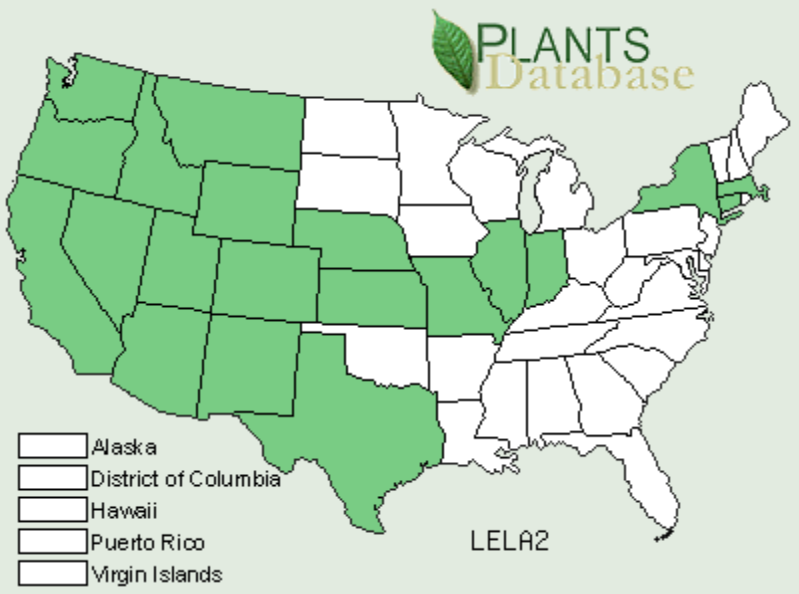
Family

Brassicaceae

Host Range/U.S. Introduction

Pepperweed is native to Europe and is widely scattered in many parts of the United States.

U.S. Range Map



Species Description

Pepperweed (*Lepidium latifolium*) is a glaucous perennial herb to 1.3 m tall with a widely spreading root system. The entire to toothed leaves are oblong and petiolate at the base, becoming smaller and almost sessile at the plant apex. The flowers are perfect and produced in a many flowered raceme. The petals are spatulate, white. The fruit is a silicle on a pedicel approximately twice as long as the silicle.

Growth Characteristics

Pepperweed is common in fields and waste places.

Problems

The aggressive nature of this plant allows it to displace native species. It is difficult to control because of its perennial root system and deep-seated rhizomes.

Canada Thistle

Canada thistle infestation along 1-90

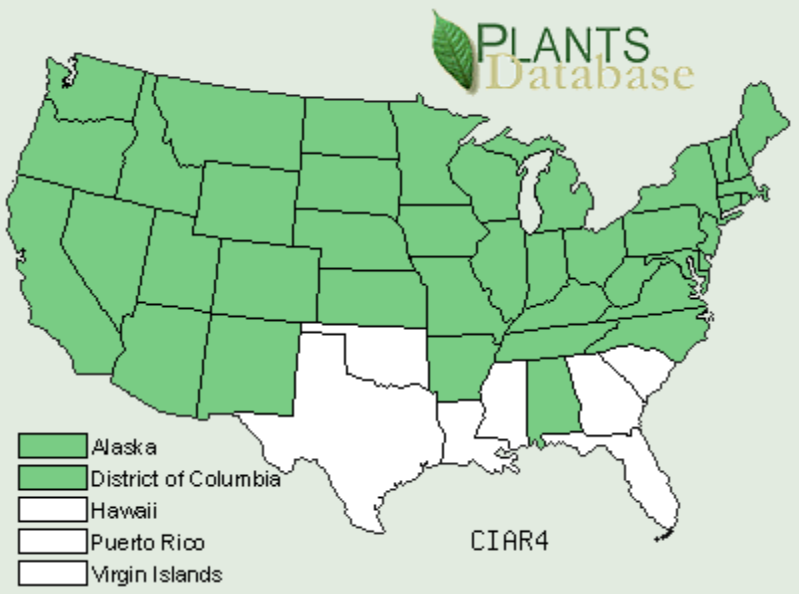
Family

Asteraceae

Home Range/U.S. Introduction

Canada thistle (*Cirsium arvense)* is native to Eurasia. It has become established in all but the southeastern part of the United States.

U.S. Range Map



Species Descriptions

Canada thistle is a dioecious perennial that spreads from deep horizontal lateral roots bearing adventitious shoots. Stems may reach up to 10 dm tall, branching near the tup. The leaves are alternate, oblong to oblanceolate, usually lobed with the margins bearing fine to strong spines. The leaf bases are sessile, clasping to short decurrent. The blades are glabrous to pubescent. The inflorescence is a head of unisexual flowers occurring in loose clusters terminating the branches. The flowers are pink to purple, rarely white. The involucral bracts are 1-2 cm, at most with a weak spine tip ca. 1 mm long. The pappus is composed of plumose bristles united in a ring at the base.

Growth Characteristics

Canada thistle is dioecious with male and female flowers on separate plants. It flowers from Jun-Aug. It occurs in pastures, ditches, bottomlands and other moist areas.

Problems

The plant is difficult to control because it spreads aggressively from horizontal roots. Plowing also breaks the root into fragments each of which can develop into a new plant.

Bull Thistle

Patrick J. Alexander @ USDA-NRCS PLANTS Database

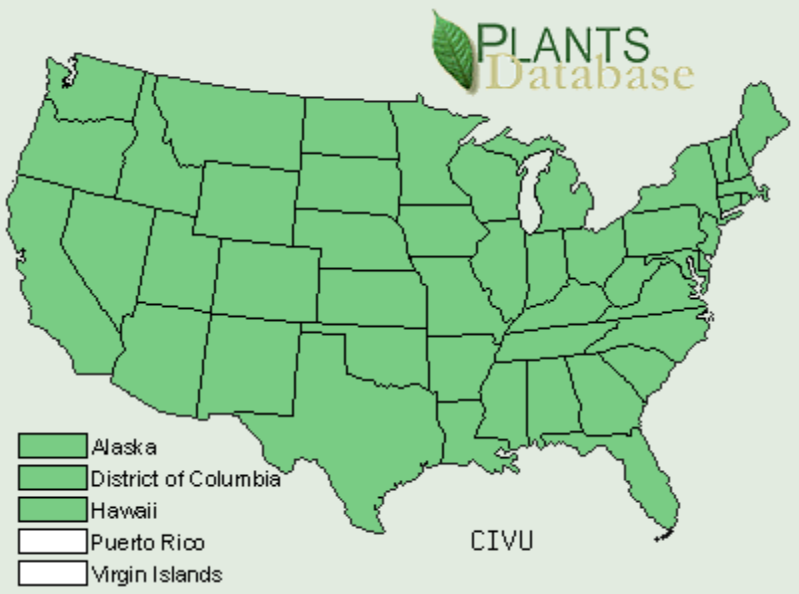
Family

Asteraceae

Home Range/U.S. Introduction

Bull thistle (*Cirsium vulgare*), native to Eurasia, is widely established in the United States.

U.S. Range Map



Species Descriptions

Bull thistle is a biennial from a short, fleshy taproot. The green to brownish stems are spreading often reaching 2 m tall. The leaves are green, the upper surface bearing yellowish prickles, the lower surface villose. The rosette leaves are oblanceolate to elliptic, deeply pinnatifid and tipped with a spine to about 10 mm long. The cauline leaves are similar to the rosette leaves but smaller, the lobes bearing stouter spines and the leaf bases strongly decurrent. The heads are numerous, terminal and solitary on the branches, appearing clustered. The flowers are dark purple. The involucral bracts are lanceolate, up to 30 mm long, and tipped with a spine. The white to tawmy pappus is composed of plumose bristles.

Growth Characteristics

Bull thistle is found in pastures, fields, along roadsides, edges of meadows, log landings, and in waste areas.

Problems

The plant is a prolific seed producer and can form dense stands. The spiny nature of the plant, its size, and its rapid spread allows it to displace other plant species and makes revegetation difficult.

Plumeless Thistle

Photo by WI DNR

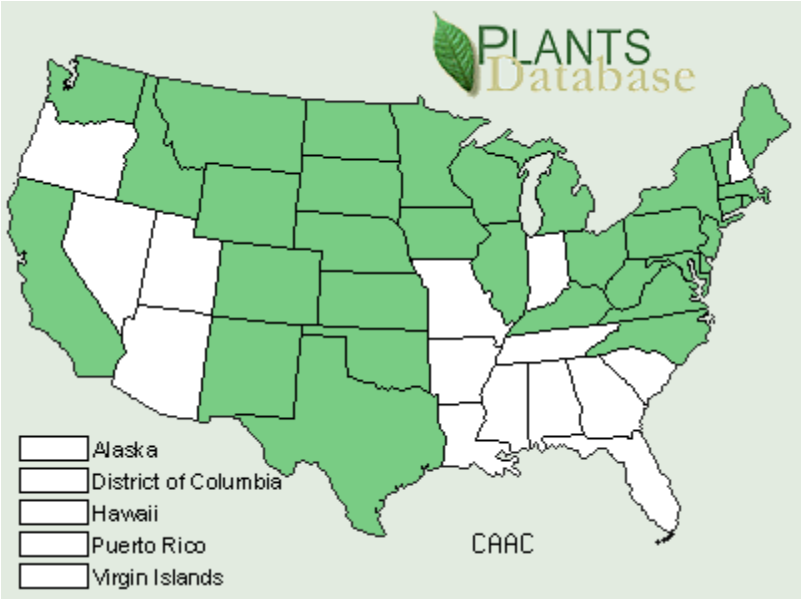
Family

Asteraceae

Home Range/U.S. Introduction

Plumeless thistle (*Carduus acanthoides*) is a native of Eurasia and is now widely established across northern United States.

U.S. Range Map



Species Descriptions

Plumeless thistle is a winter annual or biennial herb 3-10 dm tall with a stout fleshy taproot. The stems are freely branching with spiny wings extending to the flowering heads. The leaves are alternate, deeply lobed or pinnatifid with spiny margins. They are sessile, decurrent, elliptic to lanceolate or oblong in shape. The blade surface may be glabrous or pubescent. The flowers are purple in discoid heads surrounded by involucral bracts < 2 mm wide. The heads are erect, single or clustered at the ends of the branches. The pappus is composed of numerous capillary bristles 1-1.2 cm long.

Growth characteristics

The plant rarely flowers the first year. The second year, flowering occurs from May - August. It is infrequent to locally abundant in pastures, stream valleys, fields, roadsides, and waste places.

Problems

The spiny plant invades fields and pastures competing with native species or forage crops.

Musk Thistle

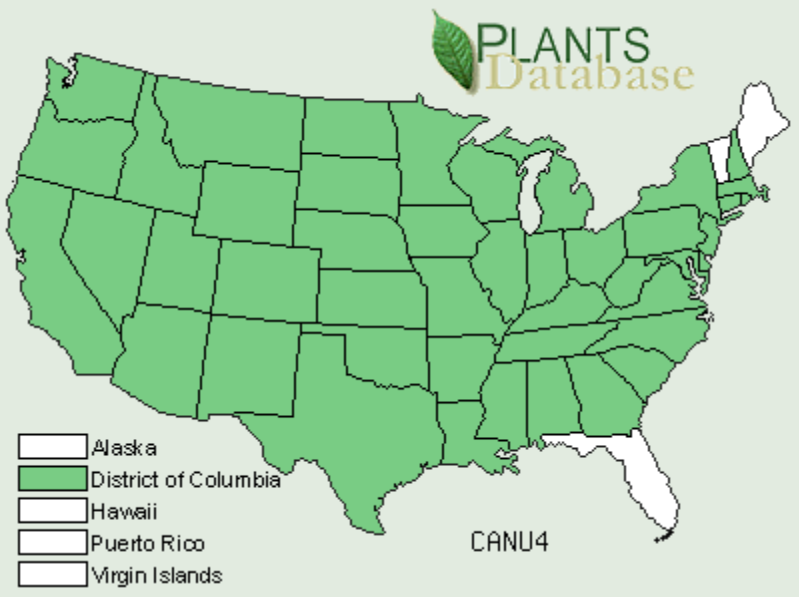
Family

Asteraceae

Home Range/U.S. Introduction

Musk thistle (*Carduus nutans*), a native of Eurasia is now widely established throughout the United States and Canada.

U.S. Range Map



Species Descriptions

Musk thistle is a winter annual or biennial herb with a stout fleshy taproot. The stems are erect up to 3 m tall, much branched, with spiny wings from the decurrent leaf bases. The rosette leaves are broadly elliptic to lanceolate, pinnatifid with spinose margins that are silvery white to purplish. The cauline leaves are alternate, sessile, decurrent, with spiny margins. The blade surface is glabrous to pubescent. The flowers are purple in discoid heads surrounded by involucral bracts 2-10 mm wide. The heads are single, terminal, and usually nodding. The pappus is composed of numerous capillary bristles 1- 2 cm long.

Growth Characteristics

The plant rarely flowers the first year. The second year, flowering occurs from May - July and sporadically to frost. It is found in pastures, stream valleys, open wooded areas, fields, roadsides, and waste places.

Problems

Musk thistle can form extremely dense stands that crowd out desirable forage species.

Cardaria spp. – Whitetop

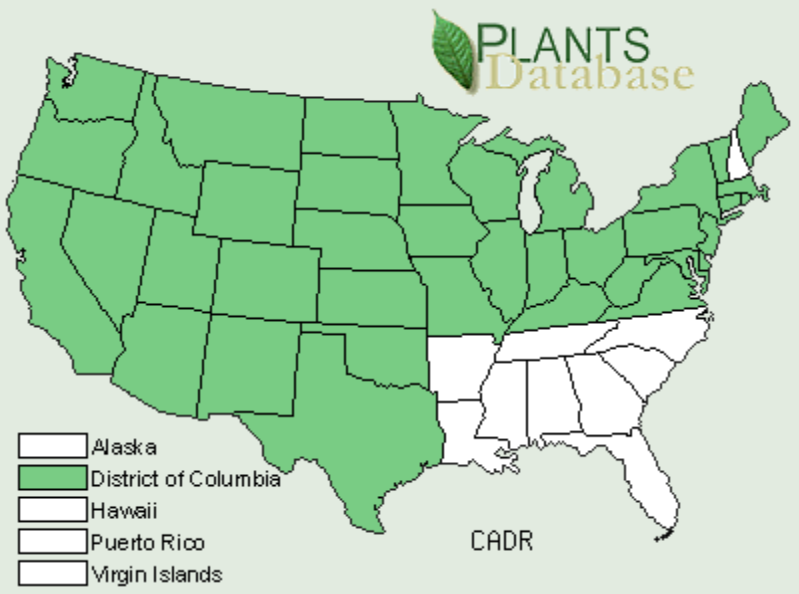
Family

Brassicaceae

Home Range/U.S. Introduction

Whitetop, (*Cardaria spp*), are native to Eurasia and are widespread throughout the United States except in the Southeast.

U.S. Range Map



Species Description

Cardaria spp. are erect perennial herbs, usually pubescent, which spread by horizontal rootstocks. Basal leaves are petiolate, lyrate when young. Upper leaves are sessile, elliptical to lanceolate, with auriculate or sagittate bases which clasp the stem. The flowers are perfect and produced in numerous dense racemes. The petals are white to cream colored and clawed. The 3 *Cardaria* species are distinguished by their texture and the shape of their fruits.

Species	**Surface**	**Shape of fruit**
C. pubescens	pubescent	inflated, subreniform to obovate
C. draba	glabrous	compressed, cordate
C. chalepensis	glabrous	compressed, subreniform to obovate

Growth Characteristics

Cardaria spp. are aggressive perennials that can reproduce by seeds or rhizomes. They are common in fields, pastures, roadsides, and waste areas.

Problems

The aggressive nature of the plants allows them to outcompete and displace native species.

Cheatgrass

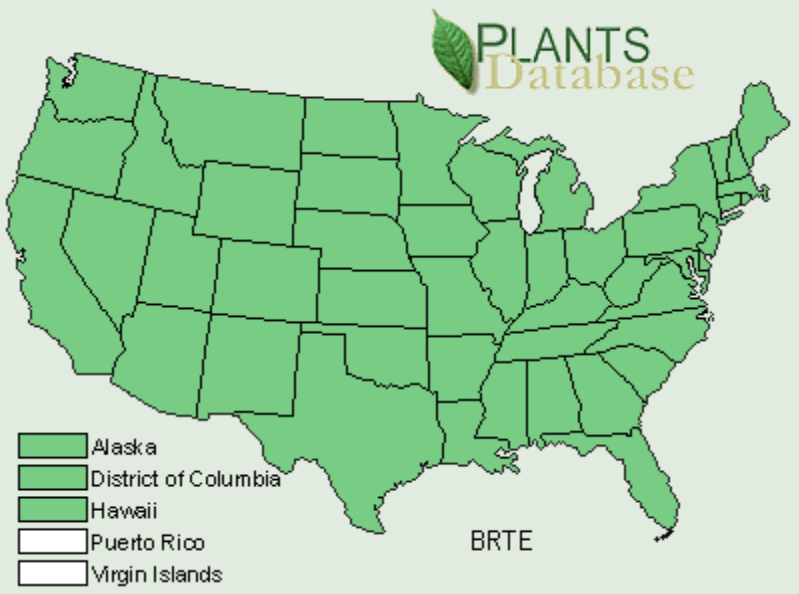
Family

Poaceae

Home Range/U.S. Introduction

This species (*Bromus tectorum* L.) was introduced from Europe, probably for forage. *Bromus* is a large genus of grasses of temperate regions of the world, many cultivated for hay or forage.

U.S. Range Map



Species Description

The plants are slender annuals with stems 30-60 cm tall. The stem nodes are glabrous. Leaf blades are up to 20 cm long, 1-6 mm wide, both surfaces and margins pubescent; sheaths are usually pubescent. The panicle is open, 5-20 cm long, 3-15 cm broad with flexuous, pubescent branches. The flowering and fruiting structures have narrow, sharp-pointed, 12- to 14-mm-long barbed points.

Growth Characteristics

Plants are tufted annuals. Plants grow along roadsides, banks, fields and waste places, commonly on the Pacific coast. They are also found throughout the U.S.

Problems

They are, at maturity, a serious pest because the pointed, barbed fruits can work into the eyes, nostrils and mouths of livestock, causing inflammation and often serious injury. Sometimes the intestines are pierced and death results. In some areas, the dry plants are fire hazards.

Asian Clam *(Corbicula Fluminea)*

Noel Burkhead - USGS

The following information has been provided by Invasive Species Specialist Group (http://www.issg.org/database)

Taxonomic name

Corbicula fluminea (Muller, 1774)

Synonyms

Corbicula leana (Prime), Corbicula fluminalis (Muller, 1774), Corbicula manilensis (Philippi, 1884)

Common Names

Asian clam (English), Asiatic clam (English), prosperity clam (English)

Organism Type

Mollusk

Corbicula fluminea is a freshwater clam that has caused millions of dollars worth of damage to intake pipes used by power, water, and other industries. Many native clams are declining as *C. fluminea* outcompetes them for food and space. C. fluminea requires well-oxygenated waters and prefers fine, clean sand, clay, and coarse sand substrates. *C. fluminea* spreads when it is attached to boats or carried in ballast water, used as bait, sold through the aquarium trade, and carried with water currents.

Description

C. fluminea has a yellowish brown to black shell with concentric, evenly spaced ridges on the shell surface (INHS 1996). They are usually less than 25 mm but can grow up to 50 to 65 mm in length (Aguirre and Poss 1999).

Occurs in: estuaries, lakes, water courses

Habitat Description

C. fluminea is found in lakes and streams of all sizes with silt, mud, sand, and gravel substrate (INHS 1996). They can tolerate salinities of up to 13 ppt for short periods (Aguirre and Poss 1999) and temperatures between 2 and 30 degrees Celsius, or 86 degrees Fahrenheit, (Balcom 1994). It prefers fine, clean sand, clay, and coarse sand substrates (Aguirre and Poss 1999). It is usually found in moving water because it requires high levels of dissolved oxygen. *C. fluminea* is generally intolerant of pollution.

General Impacts

Ecologically, *C. fluminea* can outcompete many native clam species for food and space (PNNL 2003). The introduction of *C. fluminea* into the United States has resulted in the clogging of water intake pipes, affecting power, water, and other industries. Nuclear service water systems (for fire protection) are very vulnerable, jeopardizing fire protection. In 1980, the costs of correcting this problem were estimated at 1 billion dollars annually. *C. fluminea* causes these problems because juveniles are weak-swimmers, and consequently they are pushed to the bottom of the water column where intake pipes are usually placed. They are pulled inside the intakes, where they attach, breed, and die. The intake pipes become clogged with live clams, empty shells, and dead body tissues. Buoyant, dead clams can also clog intake screens.

Uses

In *C. fluminea's* native range, it is marketed for human consumption and as feed for domestic fowl (Aguirre and Poss 1999). In the United States, it is sold as fish bait (Aguirre and Poss 1999), and it is sold through the aquarium trade where they are known as "pygmy" or "gold" clams.

Geographical Range

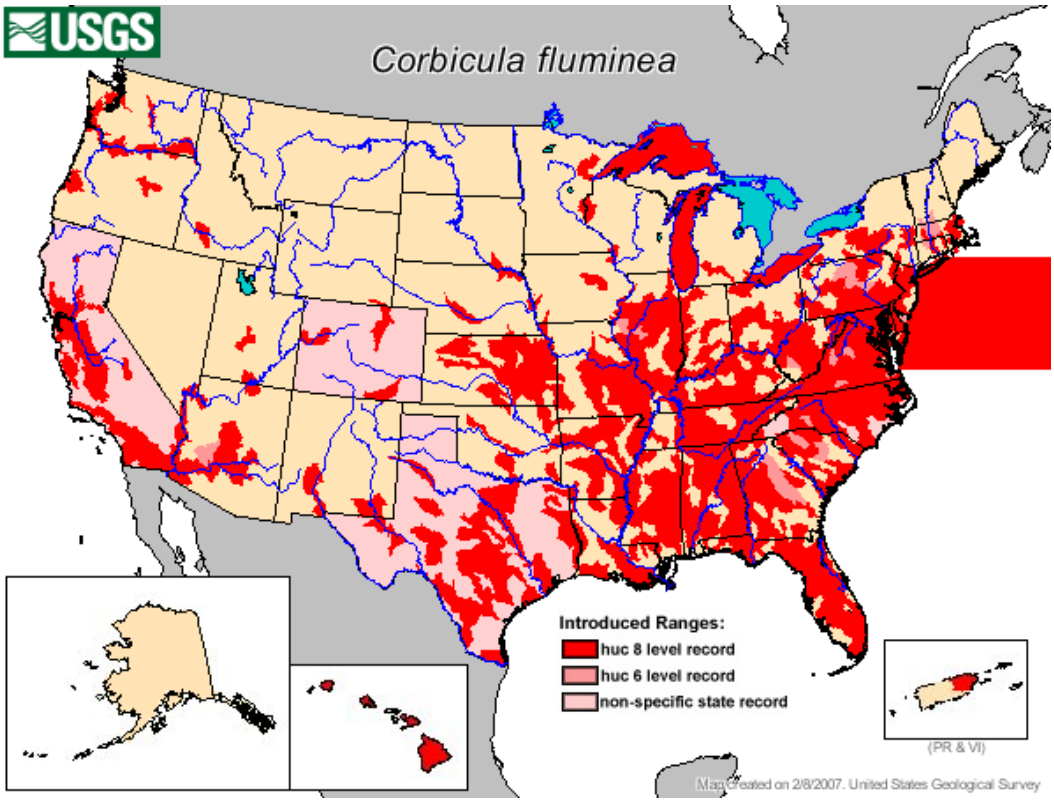
Native Range

C. fluminea is native to southeastern China, Korea, southeastern Russia, and the Ussuri Basin (Aguirre and Poss 1999).

Known Introduced Range

In the United States, *C. fluminea* has been introduced to 38 states and the District of Columbia (Foster *et al.* 2000).

U.S. Range (from USGS)



Invasion Pathways to New Locations

Other: Used as live bait throughout the United States. The clams sometimes escape into the water alive.
Pet/aquarium trade: C. fluminea is known as "pygmy" or "gold" clams in the aquarium trade.
Ship ballast water: Juvenile clams can be carried in ballast water all over the world.
Ship/boat hull fouling:

Local Dispersal Methods

Boat:
Escape from confinement: Researchers sometimes inadvertently release C. fluminea into non-native waters.
Water currents: Water currents spread juveniles throughout a water body.

Management Information

C. fluminea populations are controlled by a variety of methods. Where intakes pipes are fouled, thermal regulation is employed, whereby water in the pipes is heated to temperatures exceeding 37 degrees Celsius. But this method is not possible in most existing water systems. Mechanical measures, such as using screens and traps, can effectively eliminate older clams and remove body tissue and shells from the system. Chemicals, such as small concentrations of chlorine or bromine, are used to kill juveniles and sometimes adults. This method is very effective, but because of increasing restrictions on the amounts of these chemicals that may be released from a facility, facility managers have been moving away from this method. Some states have legislation prohibiting the introduction of C. fluminea into their waters.

Nutrition

C. fluminea feeds on plankton.

Reproduction

C. fluminea is a hermaphrodite (both sexes are found on one organism) and is capable of self-fertilization. Sperm is released into the water, caught by another clam, and brooded in the gills. The larvae are released through the excurrent siphon and sent out into the water column. Spawning can continue year around in water temperatures higher than 16 degrees Celsius. The water temperature must be above 16 degrees Celsius for the clams to release their larvae. In North America, spawning occurs from spring to fall (Aguirre and Poss 1999). Maximum

densities of *C. fluminea* can range from 10,000 to 20,000 per square meter, and a single clam can release an average of 400 of juveniles a day (PNNL 2003) and up to 70,000 per year. Reproductive rates are highest in fall (Aguirre and Poss 1999).

Lifecycle Stages

Larvae spawned late in spring and early summer can reach sexual maturity by the next fall (Aguirre and Poss 1999). *C. fluminea* maximum lifespan is 7 years, but it varies according to habitat (Aguirre and Poss 1999), with an average lifespan of 2 to 4 years (PNNL 2003).

Reviewed by: Anon

Principal sources: Balcom, N. C. 1994. *Aquatic Immigrants of the Northeast, No. 4: Asian Clam, Corbicula fluminea.* Connecticut Sea Grant College Program.

Compiled by: National Biological Information Infrastructure (NBII) and Invasive Species Specialist Group (ISSG)

Last Modified: Monday, 24 January 2005

New Zealand Mudsnail *(Potamopyrgus Antipodarum)*

Photo by D.L. Gustafson

The following information has been provided by Global Invasive Species Database, 2005, *Potamopyrgus antipodarum* (mollusk), available from: http://www.issg.org/database/species/ecology.asp?si=449&fr=1&sts [Accessed 8 February 2007]

Taxonomic Name

Potamopyrgus antipodarum (Gray, 1843)

Synonyms

Hydrobia jenkinsi (Smith, 1889), Potamopyrgus jenkinsi (Smith, 1889)

Common Names

Jenkin's spire shell, New Zealand mudsnail

Organism Type

Mollusk

Potamopyrgus antipodarum is an aquatic snail native to New Zealand and introduced to Australia, Europe, and North America. It can inhabit a wide range of ecosystems, including rivers, reservoirs, lakes, and estuaries. *P. antipodarum* can comprise over 95% of the invertebrate biomass in a river and it is suspected that it can alter primary production in some streams. They can spread rapidly in introduced areas and are able to withstand desiccation, a variety of temperature regimes, and are small enough that many types of water users could be the source of introduction to new areas.

Description

P. antipodarum is a small, aquatic snail. Richards et al. (2002) state that the operculum is like all prosobranchs but that *P. antipodarum* "has an operculum to block the shell aperture when the animal is withdrawn into its shell. This is easily seen on live snails, but the operculum is lost from dead shells and it is normally withdrawn beyond view in shells that are directly preserved in alcohol or formalin." The authors also state that "the shell is normally horn colored but ranges from light to dark brown. Encrusted shells can be any color. Almost all western populations reach a maximal size very near 5 mm. One population in Idaho (Cassia Creek of the Raft River) regularly pushes 6 mm. The shell is rather elongate compared to most western species. Like most snails, it is dextral (opening to the animal's right). A full-grown shell normally has 5 or 6 whorls, which is higher than most western species. In some western populations, a weak keel is present about mid whorl in some to most individuals. Many populations lack this keel entirely. This keel is not present on any native western snail species."

Occurs in: estuaries, lakes, water courses

Habitat Description

Richards *et al.* (2002) state that *P. antipodarum* has "a wide range of tolerances: rivers, reservoirs, lakes, and estuaries. Densities are usually highest in systems with high primary productivity, constant temperatures, and constant flow." In rivers it is found in all habitat substrates; silt, sand, gravel, cobbles, and vegetation (Richards et al. 2001, In Richards et al. 2002). In estuaries *P. antipodarum* can tolerate up to 17-24% salinity (Bondesen and Kaiser 1949, in Richards et al. 2002). Mud snails are able to withstand desiccation and a variety of temperature regimes (National Park Service, Undated).

General Impacts

USGS-FISC (Undated) states that *P. antipodarum* "densities of over one-half million per meter square in western streams are a cause for concern. Because the West is known for abundant trout and productive fishing spots, there is concern that *P. antipodarum* will impact the food chain for native trout and the physical characteristics of the streams themselves." Richards *et al.* (2002) report that "frequently, *P. antipodarum* will comprise over 95% of the invertebrate biomass in a river. To date, limited research has documented decreases in native macroinvertebrate populations in several rivers where P. antipodarum has invaded. *P. antipodarum* has also been shown to drastically alter primary production in some streams. Its invasion has generated much concern about the potential impacts it may have on native species, fisheries, and aquatic ecosystems in the western USA." The National Park Service (Undated) states that "these small mollusks have the potential to 'cover the stream bottom,' similar to impacts observed with the Zebra mussel (*Dreissena polymorpha*) in the midwestern U.S. Preliminary baseline surveys indicate that *P. antipodarum* may be impacting the invertebrate community in the Madison, Firehole, and Gibbon rivers not only through physical displacement or crowding, but also through competitive interactions such as food availability. These streams not only support world famous recreational fisheries, but they also historically contained an abundance of native aquatic insects that form an important part of the aquatic food chain. Reductions in the insect species diversity or abundance could diminish the availability of this critical food resource to fish. Mud snails are a poor substitute for the traditional food base, yielding as little as 2% of their nutritional value when eaten by trout."

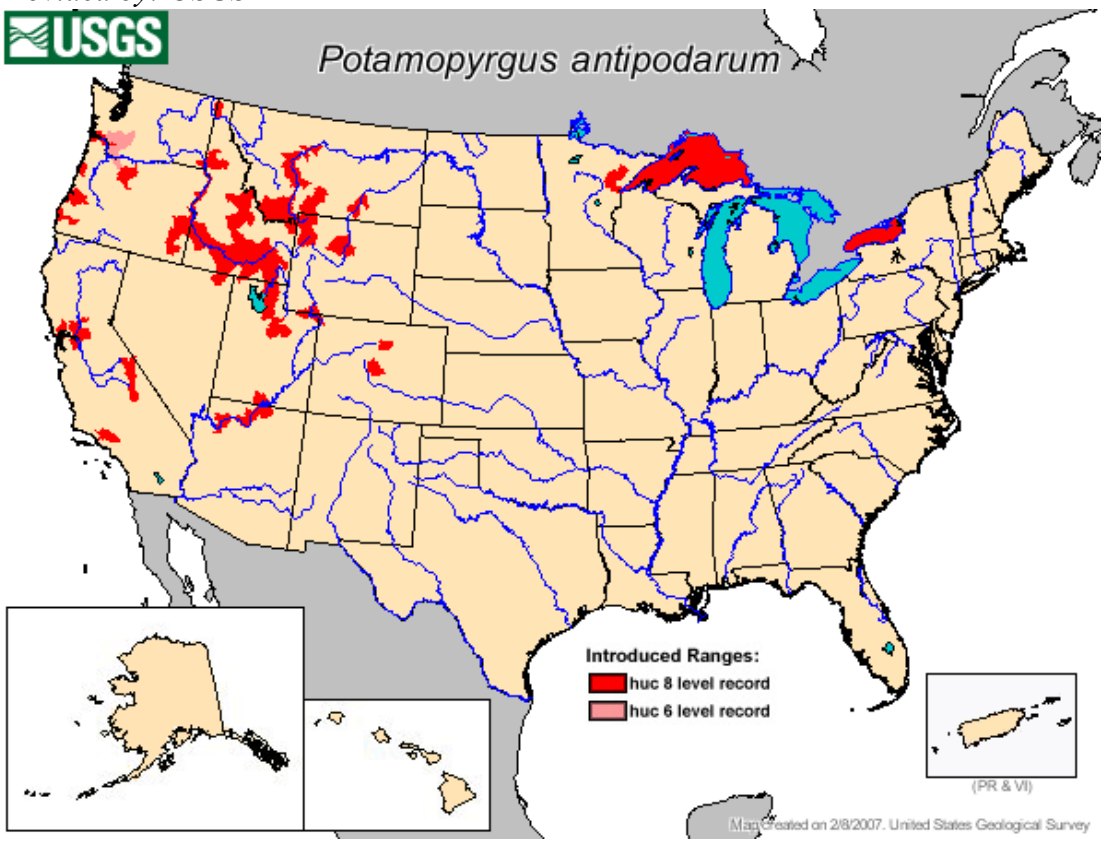
Notes: Lively (Undated) reports that "genetic studies have shown that asexual lines are derived from sympatric sexual females and that clonal diversity in mixed populations is very high (Dybdahl & Lively 1995, in Lively, Undated).

Geographical Range

Native range: New Zealand (USGS-FISC, Undated).
Known introduced range: Europe, Australia, and North America (USGS-FISC, Undated)

Range Map

Provided by: USGS



http://nas.er.usgs.gov/queries/FactSheet.asp?SpeciesID=1008

Invasion Pathways to New Locations

Ignorant Possession

The National Park Service (Undated) states that "the rapid spread of *P. antipodarum* throughout the Madison River watershed may have been assisted by human transport. Mud snails are able to withstand desiccation, a variety of temperature regimes, and are small enough that many types of water users (anglers, swimmers, picnickers, pets) could inadvertently be the mechanism for interbasin transfer of this nuisance species."

Seafreight (container/bulk)

JNCC (2002) states that *P. antipodarum* "was introduced in drinking water barrels in ships from Australia (Ponder 1988, in JNCC, 2002). The snails were probably liberated while washing or filling water barrels or tanks and, because they can survive in brackish water, they could probably survive liberation into estuarine areas such as the River Thames."

Local Dispersal Methods

Hikers' Clothes/Boots

The National Park Service (Undated) states that "the rapid spread of *P. antipodarum* throughout the Madison River watershed may have been assisted by human transport. Mud snails are able to withstand desiccation, a variety of temperature regimes, and are small enough that many types of water users (anglers, swimmers, picnickers, pets) could inadvertently be the mechanism for interbasin transfer of this nuisance species."

Management Information

Preventative Measures

Expanding US National Park Service efforts to increase public awareness of potential threats to existing aquatic communities may be one of the best tools for containing *P. antipodarum.*

Physical

The National Park Service (Undated) states that "there are few effective treatments to completely eliminate *P. antipodarum.*" The authors go on to state that "attempts at crushing or physical removal of the snails may only exacerbate the problem by spreading eggs to new sites."

Chemical

Chemical treatment would not necessarily be selective for snails only and could eliminate remnant invertebrate populations.

Nutrition

Richards *et al.* (2002) state that *P. antipodarum* is "classified as a scraper/grazer. It prefers diatoms, plant and animal detritus, and attached periphyton."

Reproduction

Richards *et al.* (2002) states that *P. antipodarum* –ranges from 20-120 embryos per female." The authors go on to state that young are born every three months in New Zealand (Winterbourn 1970, in Richards *et al.* 2002) but that they can bear young at any time of year in spring habitats in the Western United States (Richards unpublished data, in Richards *et al.* 2002), but overall they will bear young in the summer and autumn. Lively (Undated) reports that "most populations of this gastropod consist solely of triploid parthenogenetic females, but many populations also contain diploid, sexual females and males."

Lifecycle Stages

Richards *et al.* (2002) report that the lifespan of *P. antipodarum* has been observed at over a year in several marked individuals. Its growth rate depends on size. Richards *et al.* (2002) report that *P. antipodarum* "can grow 0.1 mm/day at 21 degrees C under laboratory conditions. The author also states that "in western USA *P. antipodarum* reaches sexual maturity at 3.0 mm."

Reviewed by: Dr Sabine Schreiber, Arthur Rylah Institute for Environmental Research Department of Sustainability and Environment. Australia

Principal sources: New Zealand Mudsnail in the Western USA (Richards *et al.*,2002)

Compiled by: National Biological Information Infrastructure (NBII) and Invasive Species Specialist Group (ISSG)

Last Modified: Wednesday, 26 January 2005

Zebra Mussel *(Dreissena Polymorpha)*

Benson, A. J. and D. Raikow. 2007. *Dreissena polymorpha*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=5 Revision Date: 1/10/2007

The following description is from Global Invasive Species database, 2005. *Dreissena polymorpha* Available from http://www.issg.org/database/species/ecology.asp?si=50&fr=1&sts=sss [accessed 08 February, 2007]

Taxonomic Name

Dreissena polymorpha (Pallas, 1771)

Synonyms

Mytilus polymorpha Pallas 1771

Common Names

Moule zebra (French), racicznica zmienna (Poland), zebra mussel (English), Zebra-Muschel (German)

Organism Type

Mollusk

Zebra mussels (Dreissena polymorpha) are native to the Caspian and Black Seas. They are now established in the UK, Western Europe, Canada and the USA. They compete with zooplankton for food, thus affecting natural food webs. They also interfere with the ecological functions of native mollusks and cause great economic damage.

Description

Black or brown and white striped bivalve mollusk with byssal attachment to hard substrates. Maximum size approx. 3 cm long. Shell is highly carinate, having an angle between the ventral and dorsal surfaces. Color patterns highly polymorphic, from almost pure black to unpigmented, with a variety of striped forms.

Occurs in: estuaries, lakes, urban areas, water courses

Habitat Description

Tolerates salinity to 6 ppt, temperatures to approx. 29 C, will not settle in currents greater than 2 m/sec.

General Impacts

Zebra mussels filter organic and inorganic particles between 7 and 400 microns, competing with native planktivores for food. The net result is a sedimentation of previously suspended organic matter in the form of feces and pseudofeces, shifting energy and nutrient balances from the pelagic to the benthic zone. Increases in water clarity favor increased photosynthesis by rooted aquatic macrophytes, and negatively affect fish species that prefer slightly turbid conditions, such as walleye. Removal of green algae gives cyanobacteria a competitive advantage, as zebra mussels will stop filtering in the presence of cyanobacteria. Zebra mussels settle in high numbers on native mussels (Unionidaceae), causing suffocation, starvation, and energetic stress leading to death. Loss of native mussel populations has increased dramatically where zebra mussels are present, particularly in the Great Lakes and Hudson and Mississippi rivers. Dense colonization of hard substrates is beneficial to benthic invertebrates, as habitat complexity increases as does availability of organic matter. Spawning reefs of fishes such as lake trout are negatively affected by zebra mussel colonies.

Conroy *et al*. (2005) whilst discussing implications for Lake Erie ecosystem change state that: "Dreissenid mussels represent a dynamic link between the benthic and pelagic regions of a lake ecosystem (Ackerman *et al.* 2001)". (the

benthic zone is the lowest level of all aquatic biomes. It includes the sea floor and bottom-dwelling organisms, pelagic refers to living in the water of the ocean above the bottom) The authors observe that dreissenid mussels are both a sink and source of nutrients through consumption and excretion processes, respectively and thus have an impact on the nutrient regime of the Lake.

Notes: Tolerates salinity to 6 ppt, temperatures to approx. 29 C, will not settle in currents greater than 2 m/sec.

Geographical Range

Native Range

Native range includes the Black, Caspian, and Azov seas;
Known introduced range: Since the 1700's its range has expanded westward to most of western Europe, UK, and North America, where it is found in the Great Lakes and all of the major river drainages east of the Rocky Mountains. See the USGS Nonindigenous Aquatic Species Database at Web site:
http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/maps/southwest_quagga.pdf

Invasion Pathways to New Locations

Floating vegetation/debris:
Pet/aquarium trade: Possibly via aquarium dumping.
Ship:

Ship ballast water: Introduced between continents and among Great Lakes in ballast water.
Ship/boat hull fouling: Introduced to smaller lakes by overland transport on boat hulls and trailers.
Translocation of machinery/equipment:

Local Dispersal Methods

Aquaculture (local): Larvae may be transported during fish stocking.
Boat: Adults may attach to anchors and boat hulls and be transported.
On animals: Ducks could theoretically transport larvae in wet feathers.
Other (local): Larvae may be transported on scuba diver's wetsuits, or in scientific sampling equipment.
Water currents: Range expansion within North America has been very rapid due to downstream transport of planktonic larvae.

Management Information

Numerous control methods are available to remove mussels from substrates or kill them within infested water intakes or on fouled man-made substrates; none of these methods is useful for control in the wild. Controls include mechanical removal (scraping, mechanical scrubbers in pipes), chemical (chlorine, bromine, deoxygenation), thermal, UV light, electric current, and antifouling paints (containing zinc or copper, or slick surfaces such as epozy that make removal of mussels easier). Natural predators include diving ducks, crayfish, muskrats, and fishes with grinding teeth (carp, freshwater drum, pumpkinseed, round goby, bream, roach), eel, sturgeon, flounder.

Nutrition

Filter a wide range of size particles, but select algae and zooplankton between 15-40 microns. Larval stages feed on bacteria.

Reproduction

Zebra mussels are dioecious and fertilize externally; larvae are planktonic for several weeks before settling and attaching to substrate
Estimated at up to 1.5 million eggs per female per year; survival to adult stage may be less than 1%.

Lifecycle Stages

Fertilized egg hatches into trocophore (40-60 microns, 1-2 days), several stages of free-swimming planktonic veliger lasting 8-180 days (or longer in cold water), then at 350 micron size the larvae settle as plantigrade mussels, attach to substrate as juveniles, and may mature within the first year of life under optimal conditions; maturity in the second year is more usual. Zebra mussels live 3-5 years.

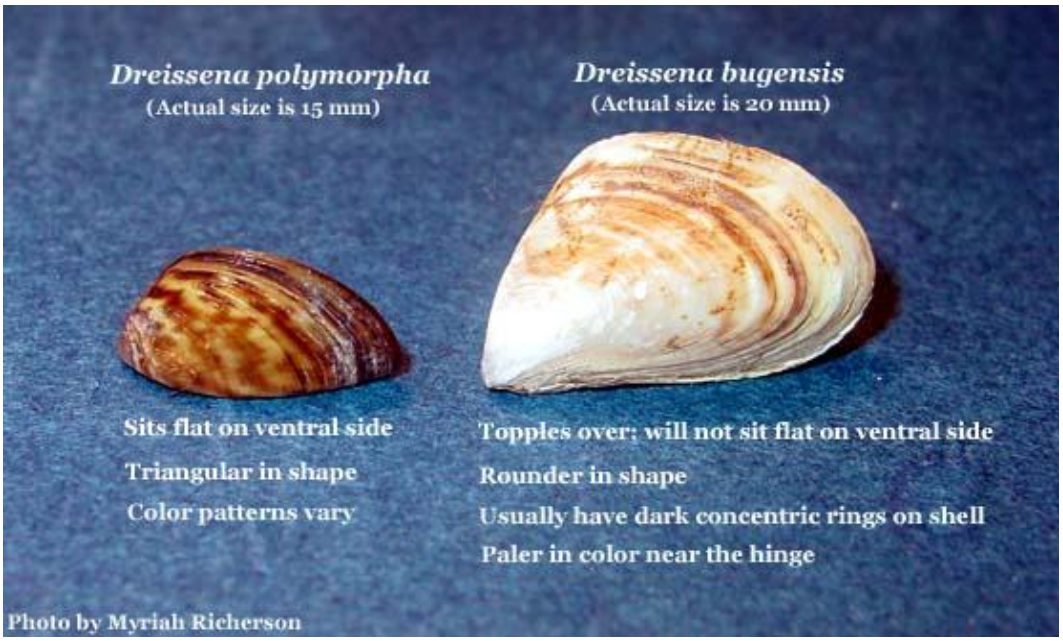
This species has been nominated as among 100 of the "World's Worst" invaders.

Reviewed by: J. Ellen Marsden, School of Natural Resources, University of Vermont, Burlington, USA.

Compiled by: J. Ellen Marsden, School of Natural Resources, University of Vermont, Burlington, USA.

Last Modified: Wednesday, 22 June 2005

Quagga Mussel *(Dreissena Rostiformis Bugensis)*



http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=95

The following description is from Global Invasive Species database, 2005. *Dreissena bugensis* Available from http://www.issg.org/database/species/ecology.asp?si=918&fr=1&sts=sss [accessed 07 November, 2007]

Taxonomic Name

Dressena bugensis Andrusov, 1987

Common Names

Quagga mussel

Organism Type

Mollusk

Dreissena bugensis is an introduced mussel native to the Ukraine. It was transported to the Great Lakes system through ballast water. It has since begun to replace *D. polymorpha* as the most dominant invasive Dreissena and is able to colonize at much deeper depths. This species is impacting zooplankton

abundance, biomass, and species composition causing decreases in native diversity and the extirpation of marine species. They have a major negative impact on recreational boating and commercial shipping as well as on raw water-using industries, potable water treatment plants, and electric power stations.

Description

D. bugensis and *D. polymorpha* are very similar in appearance but can be differentiated morphologically by their shells. *D. bugensis* has a round carina, while *D. polymorpha* a distinct carina between the ventral and dorsal surfaces. The ventral side of *D. bugensis* is convex, while the ventral side of the shell of zebra mussels is flattened. (This can sometimes be distinguished by placing shells on their ventral side: a zebra mussel will remain upright whereas *D. bugensis* will topple over). *D. bugensis* is in general more round in shape then *D. polymorpha* which is often described as having a triangular shape. *D. bugensis* has a small byssal groove on the ventral side near the hinge and *D. polymorpha* has a larger groove in the middle of the ventral side. Identification by color patterns on the shell is more difficult. Both species shells vary widely with black, cream, or white bands of dark concentric rings on the shell and some have been found that are pale or completely white. If *D. bugensis* is viewed from the front or from the ventral side, the valves are clearly asymmetrical: however, *D. polymorpha* shells are bilaterally symmetrical and join together in the midventral (Richardson 2002).

There are two phenotypes of *D. bugensis* that have now been reported in the Great Lakes: the ~~–e~~pilimnetic" form, which has a high flat shell, and the ~~–p~~rofunda" form, which has an elongate modioliform shell and has invaded soft sediments in the hypolimnion. The epilimnetic form uses its byssal threads to attach to objects and particles and form druses or colonies. The profunda morph can form colonies and attach to objects with its byssal threads or it can partially bury itself in soft sediments and extend its very long incurrent siphon above itself to bring suspended food particles (Vanderloeg et al. 2002).

Similar Species

Dreissena rostriformis

Occurs in: estuaries, lakes, water courses, wetlands

Habitat Description

Adult *D. bugensis* attach to natural hard substrata such as rocks, wood, and macrophytic plants and to man-made structures constructed of concrete, metal piping, steel, nylon, fiberglass, and wood. Attachment is by a holdfast of

proteinaceous byssal threads produced from a gland just posterior to the foot. *D. bugensis* typically occur in fresh water but thrive in salinities up to 1% and can reproduce in salinities below 2-3%. Saline intrusion exceeding 6% will cause mortality (Ussery and McMahon, 1995 and Wright *et al.* 1996).

General Impacts

D. bugensis causes changes in the structural characteristics of zooplankton like total abundance, biomass, and species composition. The general trend is a decrease in these characteristics in areas that support massive populations of Dreissena. There is an inverse relationship between zooplankton abundance and biomass and density of Dreissena mussels, which exert pressure on zooplankton (Grigorovich and Shevtsova, 1995).

Individual's byssally attach to the shells of other mussels, forming encrusting mats many shells thick (10-30cm). When such thick encrustations of mussels form on man-made structures or within raw water systems, they negatively impact their operation and efficiency. This species can have major detrimental impacts on recreational boating and commercial shipping as well as on raw water-using industries, potable water treatment plants, and electric power stations (Ussery and McMahon, 1995). A study conducted by Ricciardi *et al.* (1995) revealed that, given temperate summer conditions, adult *D. bugensis* may survive overland transport (e.g. on small trailered boats) to any location within 3-5 days drive of infested water bodies.

Notes: In both North America and its original range in Europe, *D. bugensis* is slowly dominating *D. polymorpha* populations. Some industries even built their intake structures and piping at depths to low for *D. polymorpha* colonization; however, when *D. bugensis* were discovered at lower water depths these new structures became vulnerable to colonization (Mills *et al.* 1999: and Richerson and Maynard, 2004).

Geographical Range

Native range: Ukraine: Dnieper-Bug estuary (Mills *et al.* 1996).
Known introduced range: North America: Great Lakes (Vanderploeg *et al.* 2002).
See the USGS Nonindigenous Aquatic Species Database at Web site:
http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/maps/southwest_quagga.pdf

Invasion Pathways to New Locations

Ship Ballast Water

Its release into Great Lakes waters is linked to discharge of ship ballast water (Mills *et al.* 1999).

Translocation of Machinery/Equipment

A study conducted by Ricciardi *et al.* (1995) revealed that, given temperate summer conditions, adult *D. bugensis* may survive overland transport (e.g. on small trailered boats) to any location within 3-5 days drive of infested water bodies.

Management Information

Richerson and Maynard (2004) state that, ~~"~~A chemical toxicant for lake-wide control of Dreissena has not been developed mainly because it would be deadly to other aquatic life forms. Prechlorination has been the most common treatment for control, and it has found that *D. bugensis* is more sensitive to chlorination than *D. polymorpha*. This means that chlorination programs currently in use to combat *D. polymorpha* are more than sufficient to simultaneously control *D. bugensis.* Another alternative has been potassium permanganate, especially for drinking water sources, even though chemical controls are not the most environmentally sound solution." The authors list a variety of other chemical controls uses or being developed: oxygen deprivation, thermal treatment, exposure and dessication, radiation, manual scraping, high-pressure jetting, mechanical filtration, removable substances, molluskicides, ozone, antifouling coatings, electric currents, and sonic vibration.

Decreasing water levels and allowing the desiccation of *D. bugensis* is an effective, readily applied, and environmentally neutral techniques used against invasive mussels. It would be effective in raw water systems such as navigation locks and water intake structures, which are designed to be periodically dewatered for maintenance. This is a particularly attractive method of control because it could be utilized to mitigate fouling not just by *D. bugensis* but also mixed populations of this species and *D. polymorpha* (Brady et al. 1996; and Ussery and McMahon, 1995).

Fears and Mackie (1995) investigated the use of low-voltage A-C currents for preventing settlement and attachment by *D. bugensis* by using steel rods and plates with the current running through them placed near the intake of a pulp and paper plant. The results of this study showed that complete prevention of settlement of both new recruits and translocators at 8 volts/in with steel rods on both wood and concrete surfaces and with steel plate trash bars could be achieved,

and that partial prevention of settlement at 6 volts/in with steel rods on both wood and concrete surfaces and steel plates (Fears and Mackie, 1995).

Nutrition

D. bugensis are filter feeders; they use their cilia to pull water into their shell cavity where it passes through an incurrent siphon and it is here that desirable particulate matter is removed. Each adult mussel is capable of filtering one or more liters of water each day, where they remove phytoplankton, zooplankton, algae, and even their own veligers (Snyder *et al*. 1997). Any undesirable particulate matter is bound with mucus, known as pseudofeces, and ejected out the incurrent siphon. The particle-free water is then discharged out the excurrent siphon (Richerson, 2002).

Reproduction

D. bugensis is a prolific breeder. This species is dioecious and exhibit external fertilization. A fully mature female mussel is capable of producing up to one million eggs preseason. After fertilization, pelagic microscopic larvae, or veligers, develop within a few days and these veligers soon acquire minute bivalve shells. Free-swimming veligers drift with the currents for three to four weeks feeding by their hair-like cilia while trying to locate suitable substrata to settle and secure byssal threads. Mortality in this transitional stage from planktonic veliger to settled juveniles may exceed 99% (Richerson, 2002).

Reviewed by: Gerald L. Mackie, Professor, Department of Zoology, University of Guelph, Guelph, Ontario Canada

Principal sources: Ussery and McMahon, 1995. Comparative study of the desiccation resistance of zebra mussels (Dreissena polymorpha) and (D. bugensis) and Richerson, 2002. DREISSENA Species FAQs, A closer look.

Compiled by: National Biological Information Infrastructure (NBII) and Invasive Species Specialist Group (ISSG)

Last Modified: Monday, 27 February 2006